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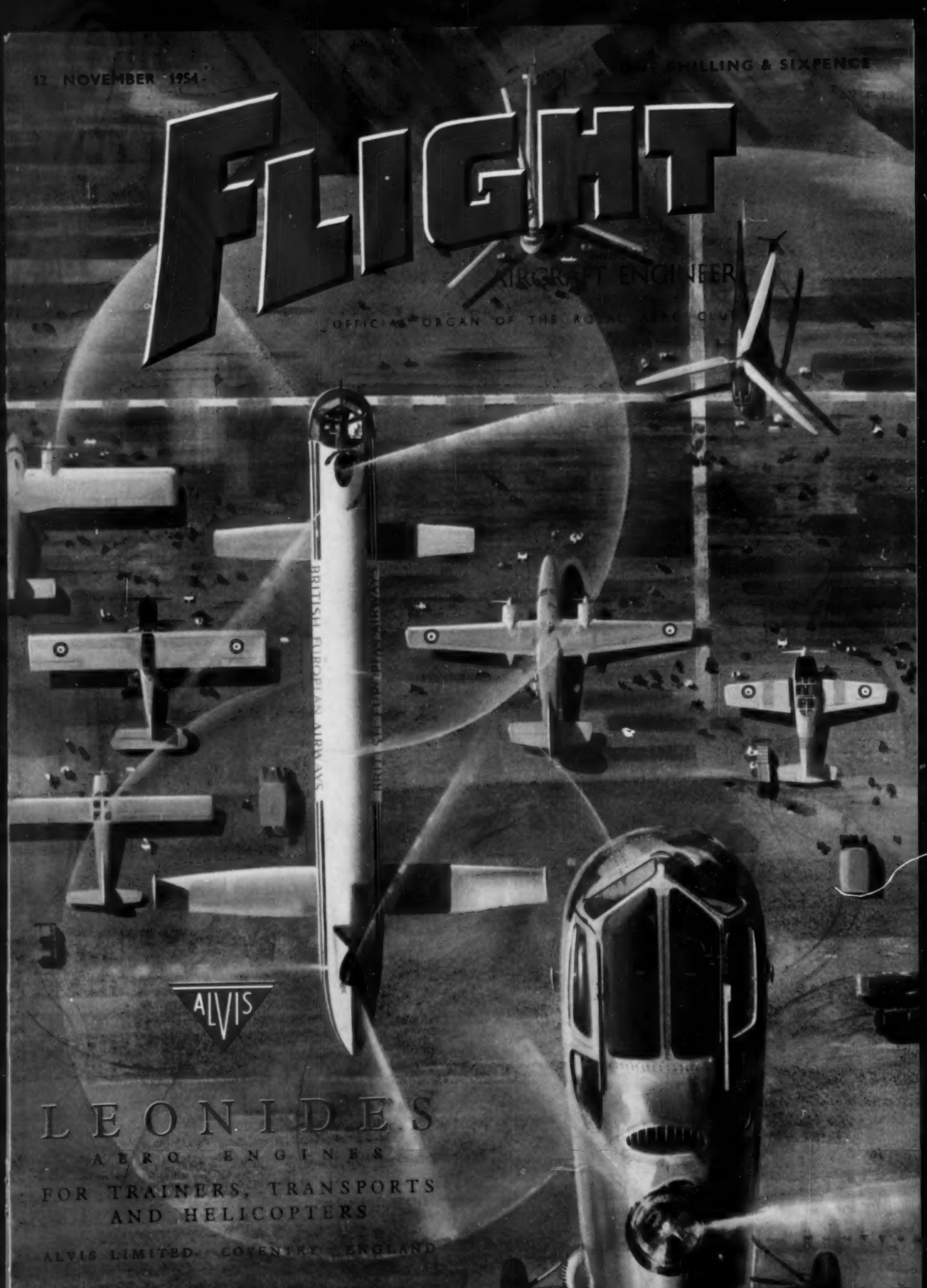

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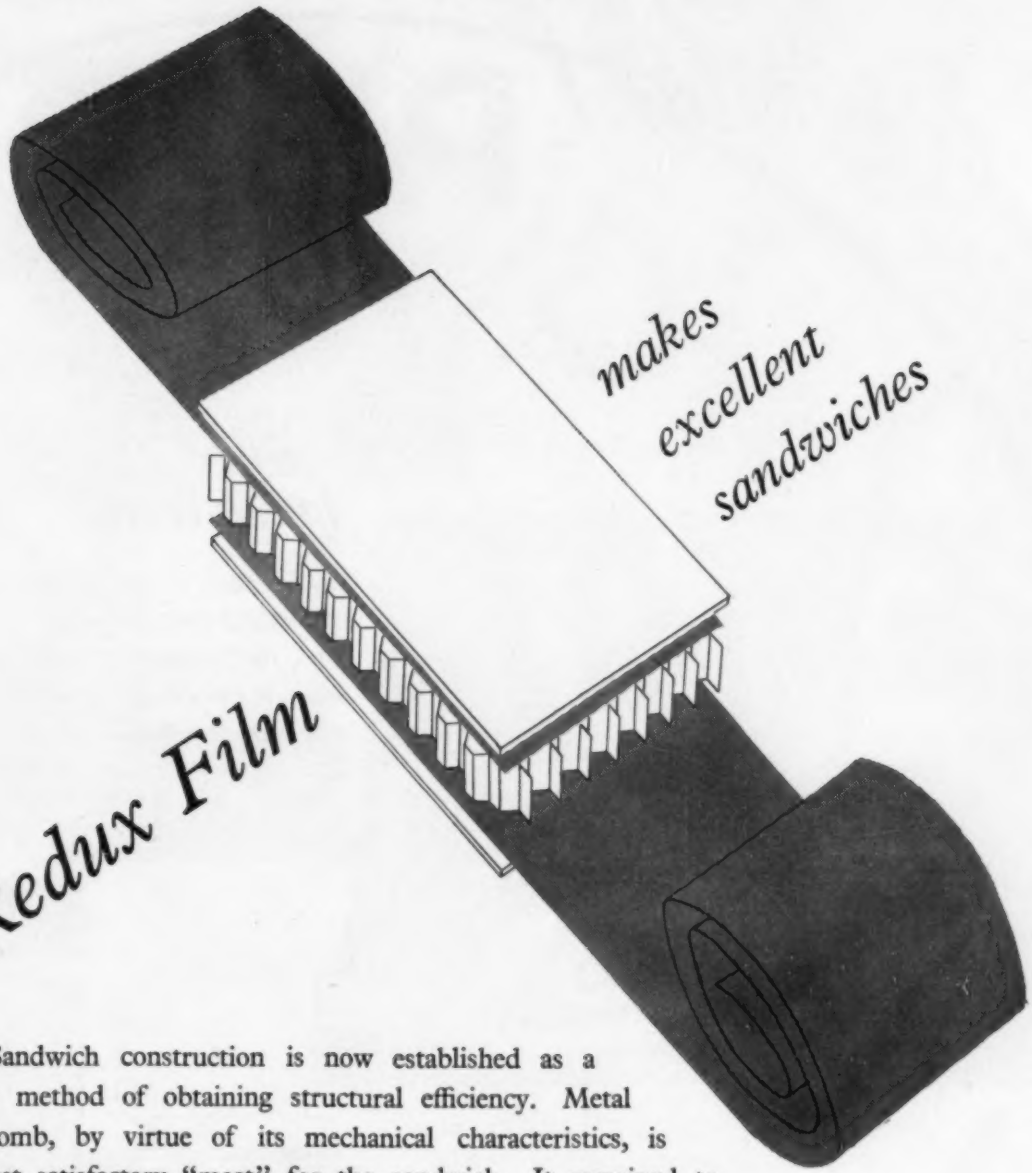

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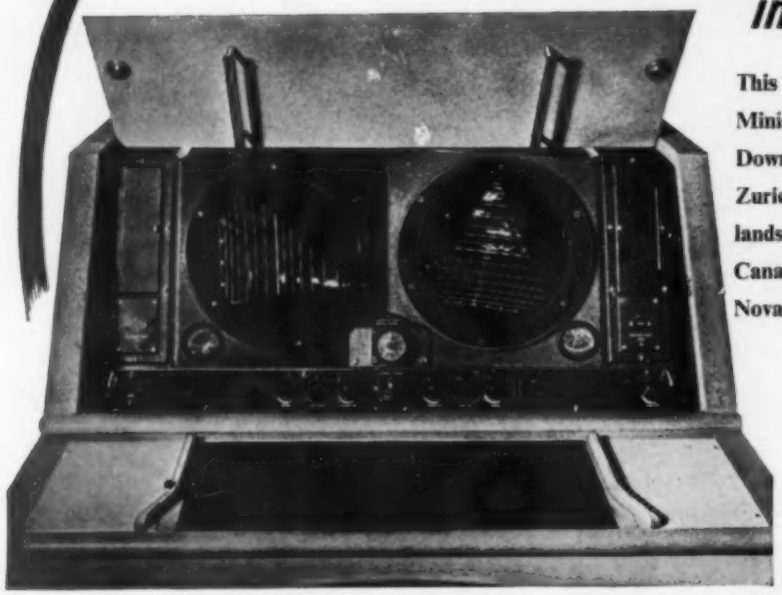

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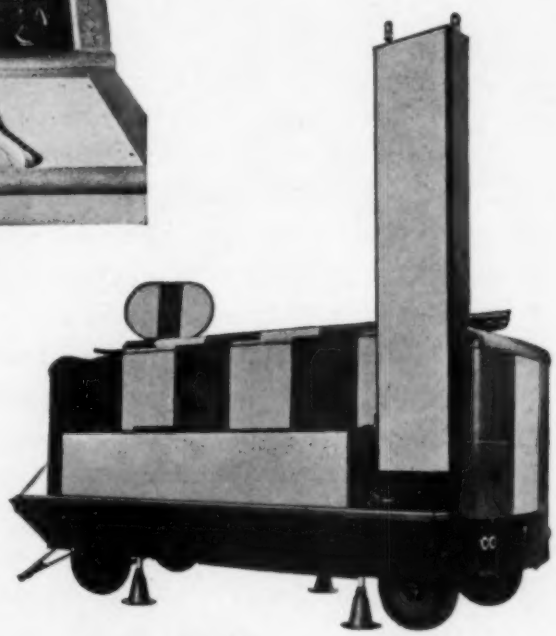

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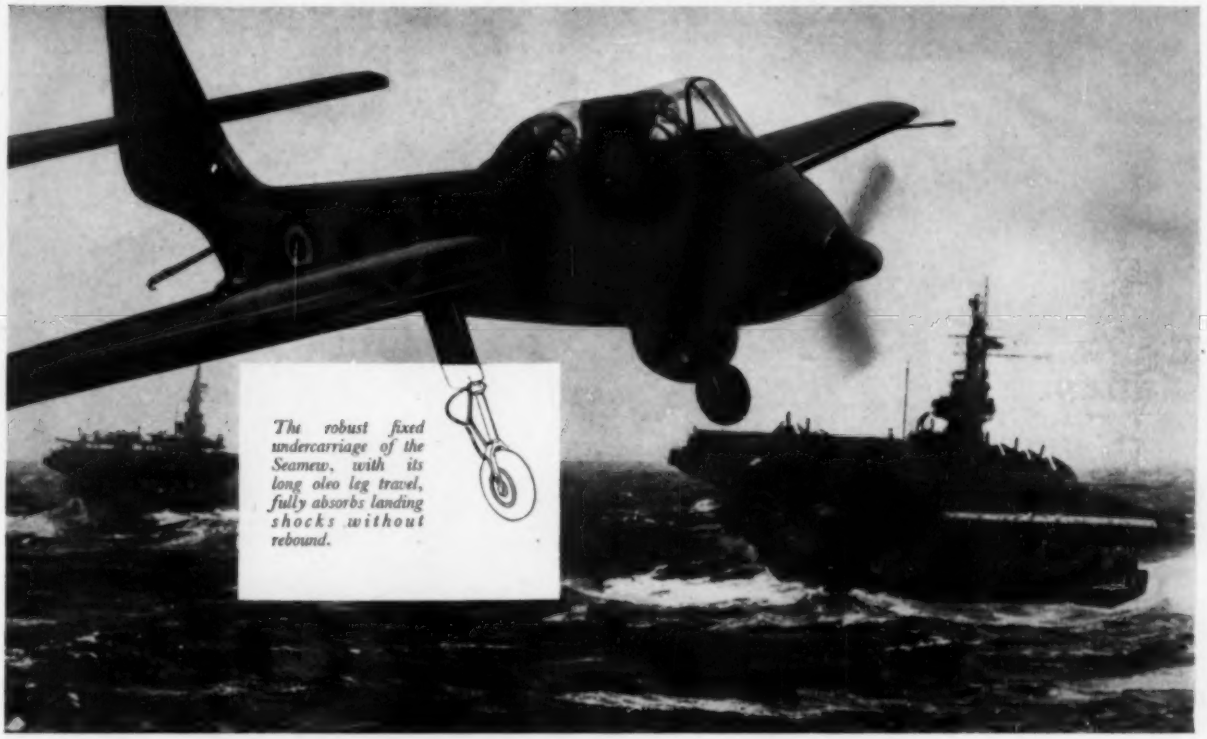
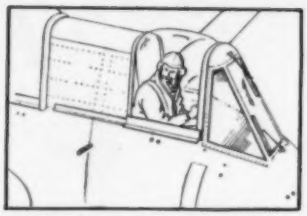
Submarine weather — *Seamew* weather

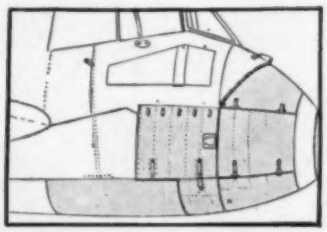


The robust fixed undercarriage of the Seamew, with its long oleo leg travel, fully absorbs landing shocks without rebound.



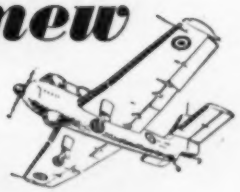
Perfect view for pilot when attacking submarine and when deck landing. Unobstructed by the single Armstrong Siddeley Mamba turbo-prop engine.

Seamew — a tough, economical, all-weather submarine hunter. In adverse weather—submarine weather—the SEAMEW can be airborne after a short take-off from the deck of an escort carrier, can conduct a radar search and low-level attack and can land back in safety—due to its slow approach speed and shock-resisting, anti-rebound undercarriage.



Economical and simple to manufacture, the Seamew doubles these advantages by simplicity of maintenance, due to accessibility of components, and by economy in servicing man-hours.

The *Short* answer is the *Seamew*



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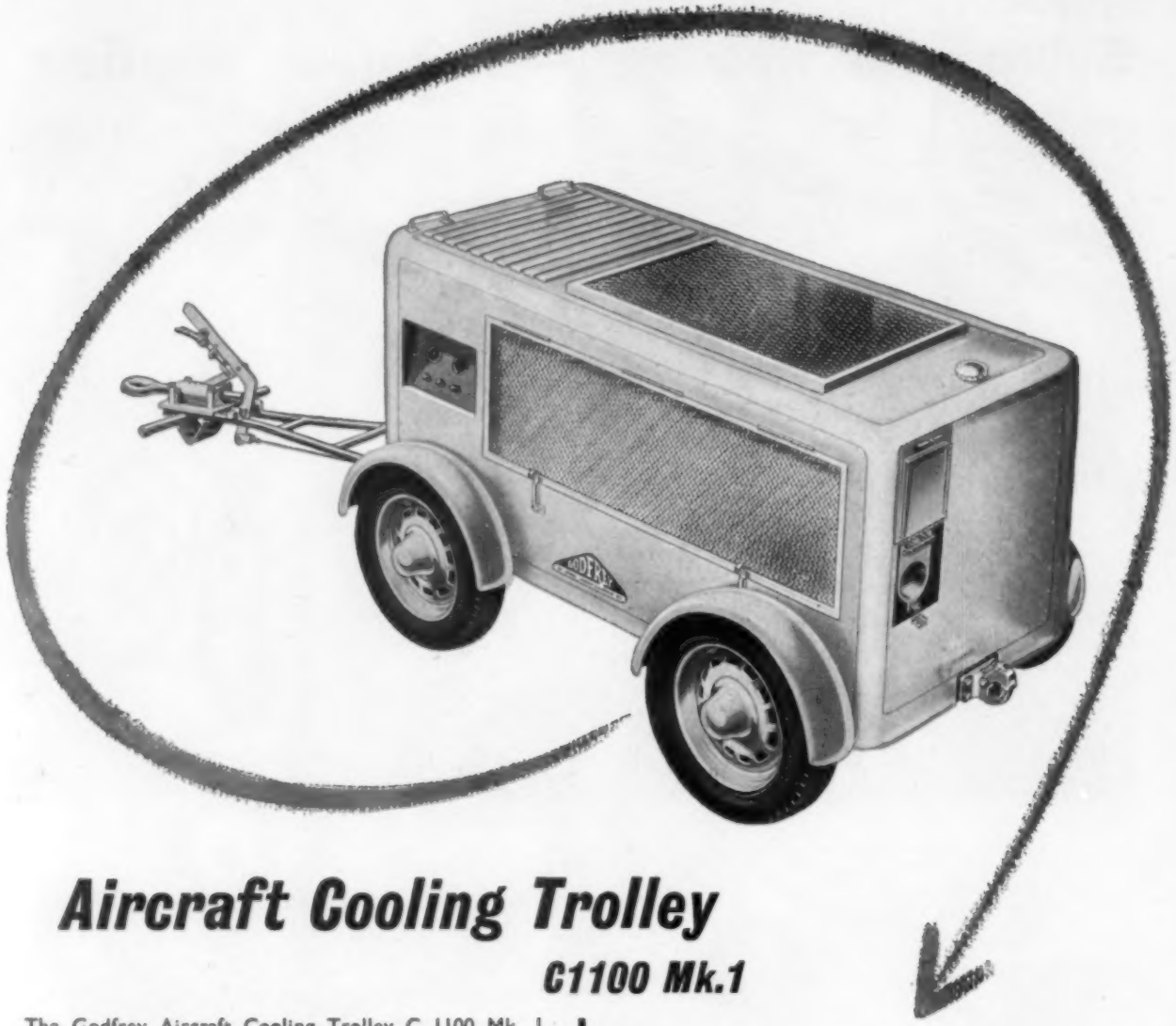

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C1100 Mk.1

The Godfrey Aircraft Cooling Trolley C 1100 Mk. I operates on the air cycle principle of refrigeration using as the working medium the charge air from a high efficiency centrifugal compressor. Designed for world-wide service, the trolley can be operated and maintained by semi-skilled labour.

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The capacity of the C 1100 Trolley makes it suitable for cooling aircraft in the Viscount class.

FEATURES:

Air cycle refrigeration · Centrifugal compressor
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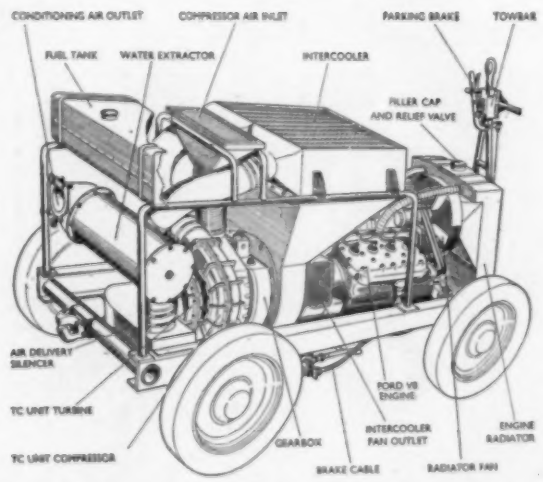
Refrigeration rating : 6½ tons



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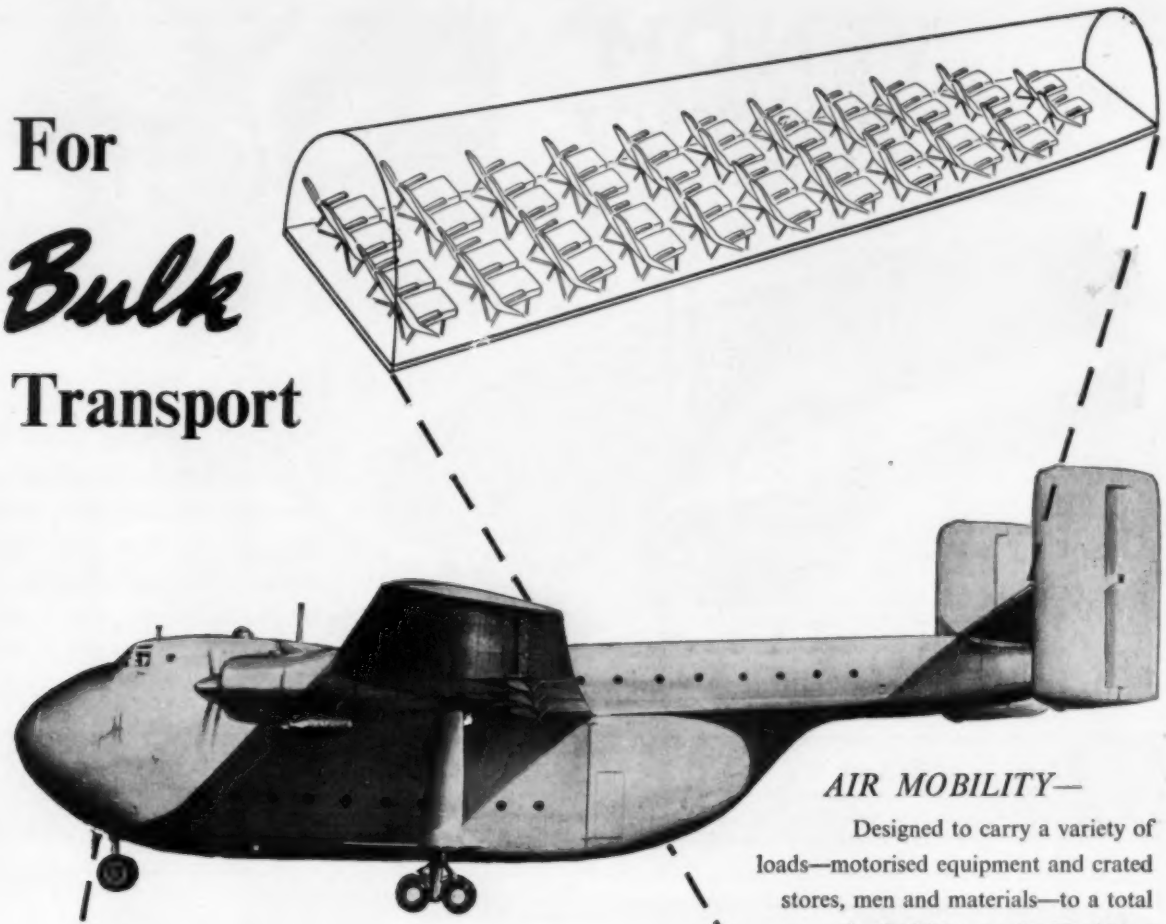

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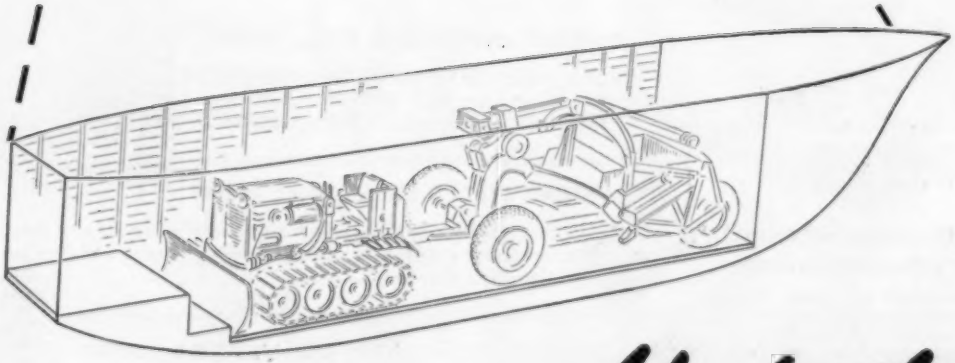

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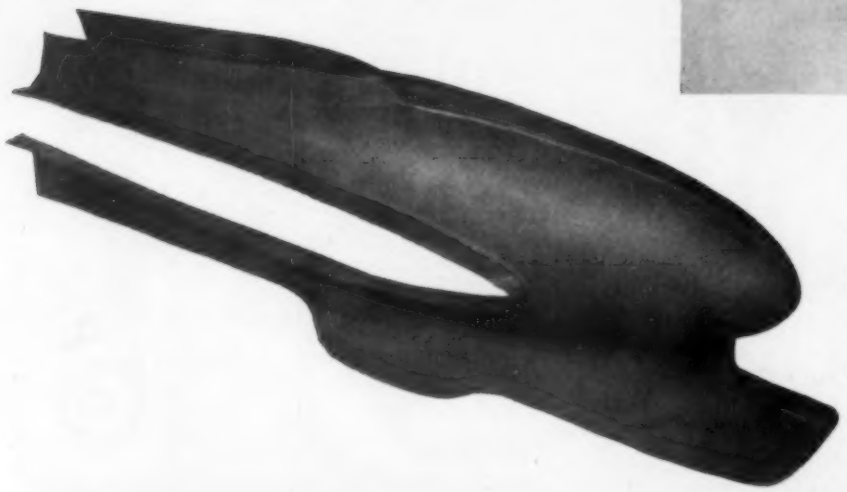

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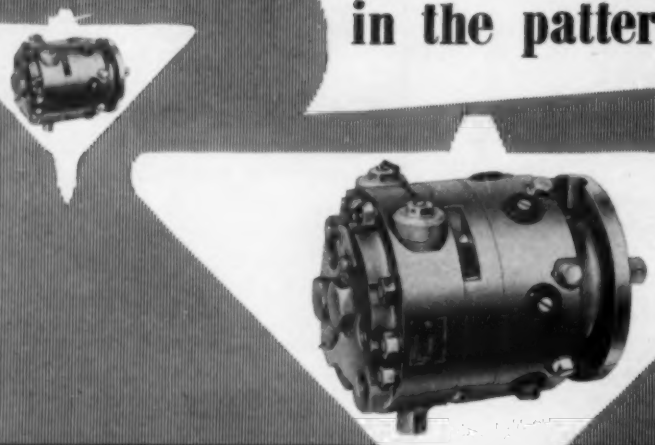

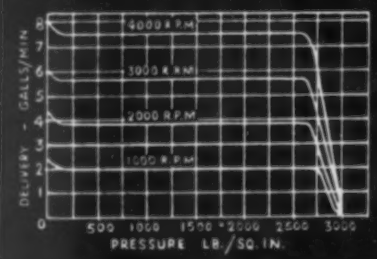

Curves show delivery/pressure characteristics for the pump type 180 Mark 5 illustrated

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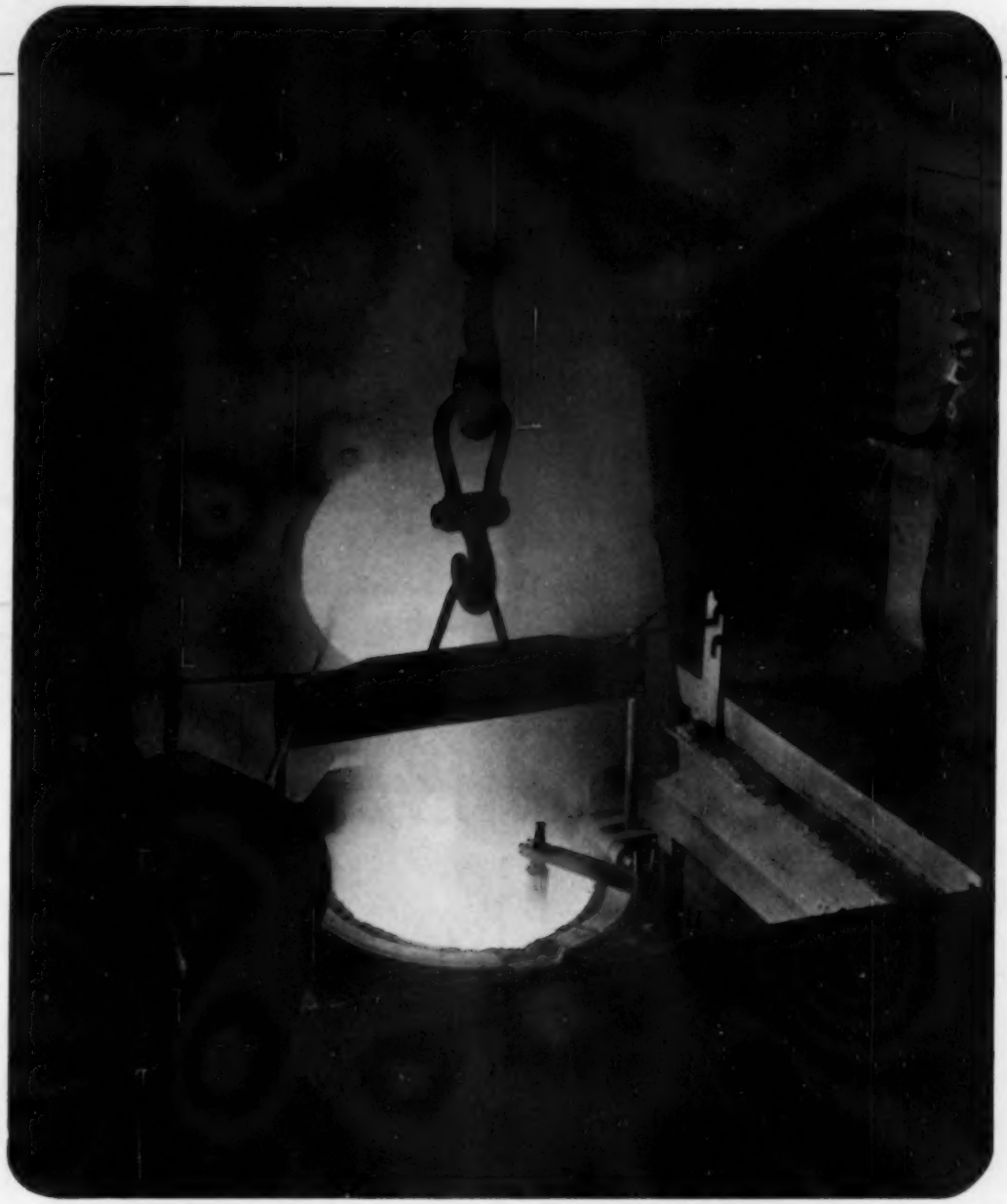

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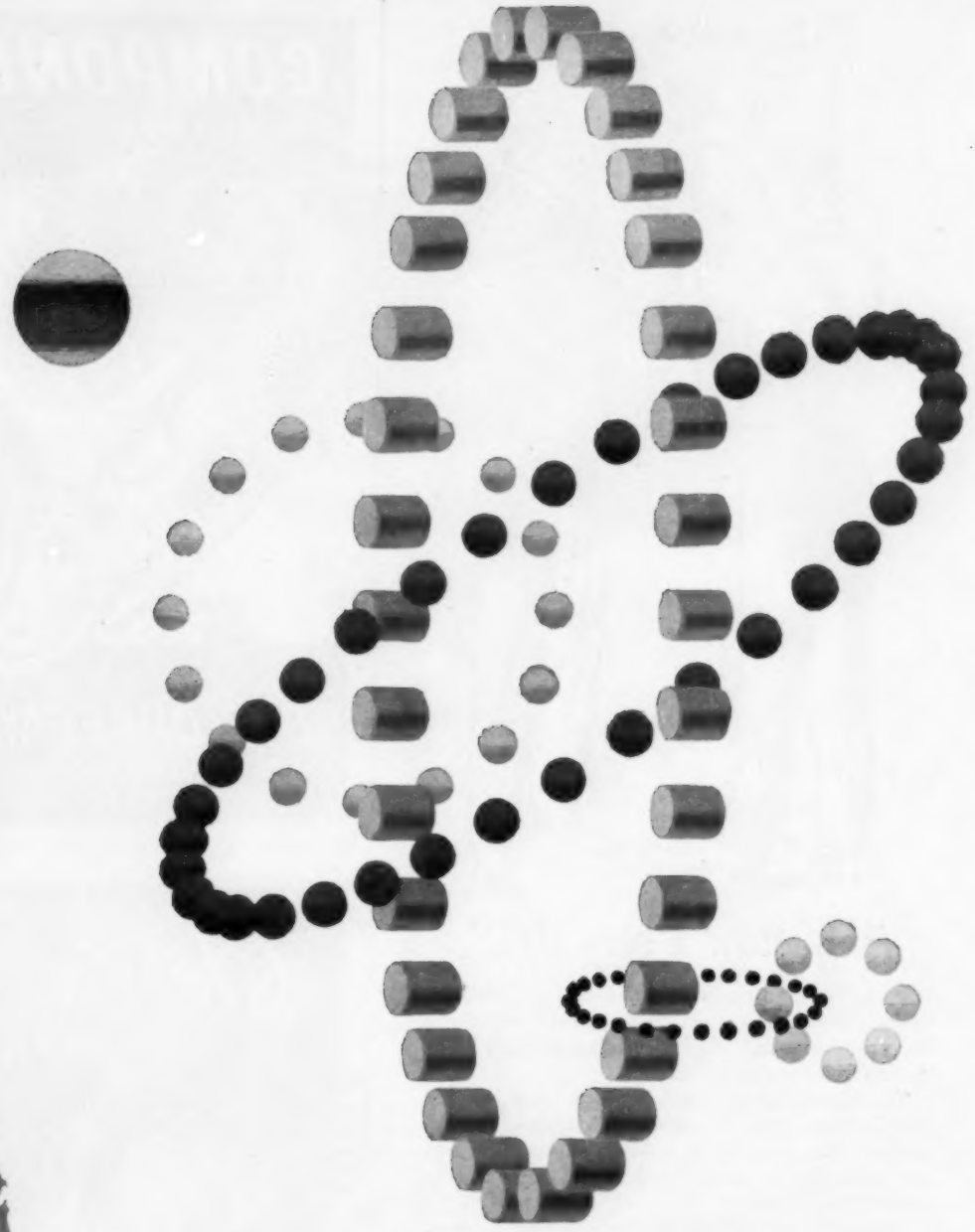

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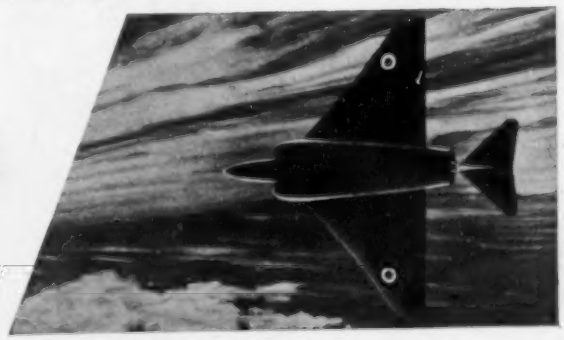

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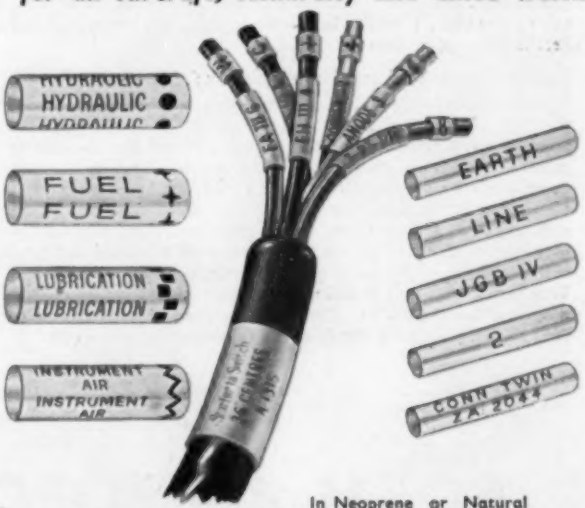

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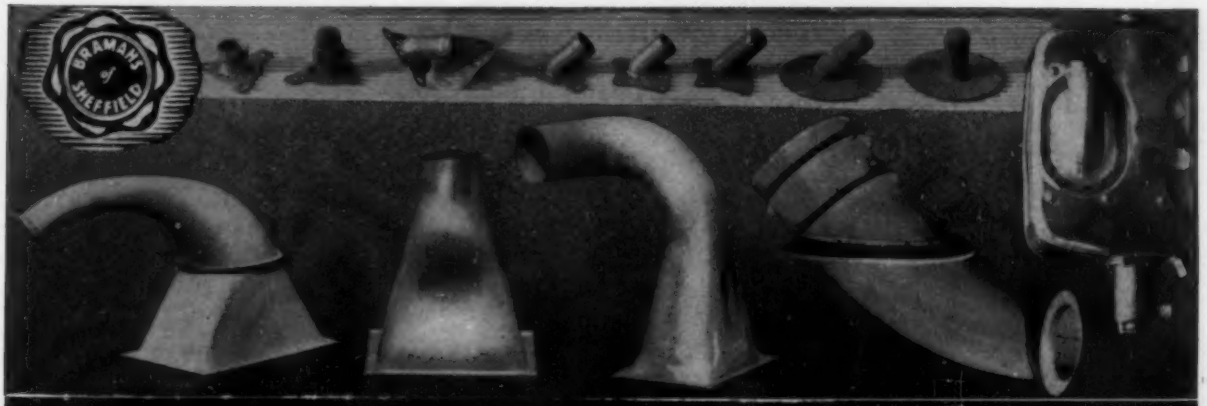

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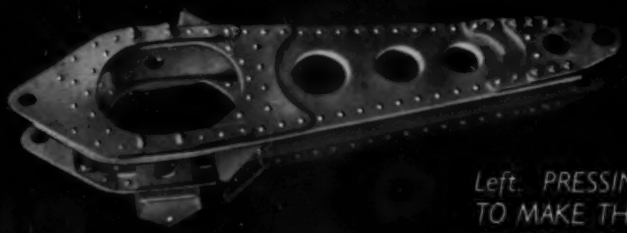

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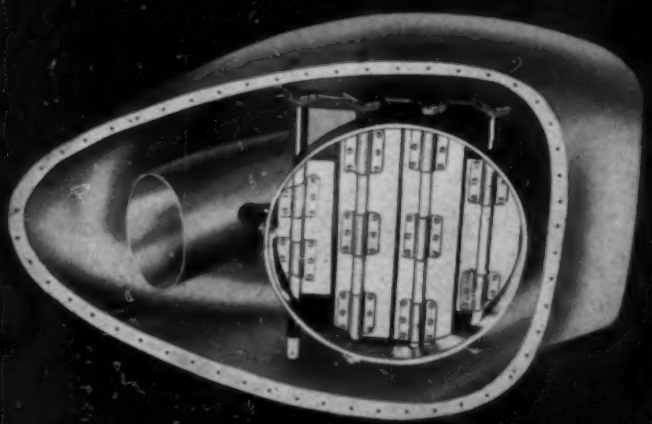
Right & Below AIR INTAKES CONSTRUCTED FROM PRESSINGS



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Thoughts on Uplift

ONE of the remarkable aircraft designs conceived and drawn by Sir George Cayley was for a convertiplane; this and many other ideas and experiments which were the work of the far-seeing Yorkshireman were referred to by Capt. Laurence Pritchard in his R.Ae.S. lecture at Hull last week (see pages 701-703). On this occasion it happened that the chair was taken by Mr. A. G. Elliott, joint managing director of Rolls-Royce, and thus it came about that jet lift and vertical take-off were mentioned on more than one occasion during the evening. Cayley had no power available to him except a steam engine estimated at 200 lb/h.p., and while he accurately predicted the basic characteristics of an air expansion or internal combustion engine, and spoke of a directional mouthpiece from a ducted fan, there is no record to indicate that he foresaw the use of jet thrust as we know it today. Had he been able to obtain or build a suitable engine Cayley might have forestalled (a not inappropriate word, perhaps) the Wright brothers by as much as 70 or 80 years.

Today, so far as the concept is concerned, we have made only a little progress beyond Cayley's idea for a convertiplane. Most of that progress has been achieved in recent years and the next decade will certainly see some remarkable machines designed to rise and alight vertically but otherwise to proceed forward at speed.

We believe that the helicopter is here to stay—for a long time. Yet it is not without significance that very few of the long-established aircraft manufacturers in America or England have turned their attention to these machines. Some admit that they are not interested at all; others say the helicopter of today is ideal only to demonstrate vibration and fatigue. A glance at the extraordinarily different approaches to the design of helicopters is indicative of the lack of agreement even on basic configuration.

Opinions regarding V.T.O. machines are, in our experience, even more varied. Some say the possible advantages are outweighed by the disadvantages for every duty; others that for military purposes alone V.T.O. is the coming thing. Again, take-off attitude is regarded by some people as the crux of the matter. For an intercepter it may be practical for the pilot to turn through 90 degrees and thus permit the machine to "fly" vertically and then round over to the horizontal. Passengers in airliners, on the other hand, would not stand for such treatment; thus the thrust—jet, airscrew or rotor—must change direction through 90 degrees or, alternatively, two engines or groups of engines must be provided, one for take-off and the other for forward propulsion. Still another variation of the theme is provided by the Fairey Rotordyne, which uses one pair of engines but two systems for absorbing their power together or separately in proportions selected by the pilot.

About one thing everyone seems to agree: that all flying machines capable of rising vertically should gain flying speed as soon as possible after leaving the ground. In the case of intercepters this may, of course, mean vertical flying speed.

The American turboprop vertical risers for research are reasonably conventional aircraft in layout. They are interim tail-sitters but depend upon aerodynamic controls operating in the slipstream of the airscrews alone, when upward (forward) speed is low or negative. In this case the transition to horizontal flight (see overleaf) presents no great difficulty. With jet V.T.O., directional jet thrust is required for control as well as for lift. Rolls-Royce's bedstead was designed simply to test jet controls. Opposed Nenes were chosen as being readily available and providing reliable thrust with balanced torque. It may be presumed that a later stage will include transition to forward flight and back to vertical for landing. The American Bell company have a jet V.T.O. machine for similar trials, and an Avon-powered Ryan is reported. It is our guess also that Avro Canada's project Y may materialize in the same broad class.

Such machines as these might eventually employ two kinds of controls: directional jets for vertical and slow-speed flight over landing areas, and conventional hinged surfaces for use in transit.

These thoughts and observations give promise of a fascinating period of trials and development lying immediately ahead of us. If we may use Cayley's terminology, they could lead to revolutionary changes in the design of carriages for aerial navigation.

FROM ALL QUARTERS

Royal Visit to English Electric

BRITAIN'S first supersonic fighter, the English Electric P.1A prototype, gave its first display of exhibition flying on November 3rd, when the Duke of Edinburgh visited the English Electric Company's airfield at Warton, Lancs. Flown by the firm's chief test pilot, Mr. R. P. Beamont, the P.1 showed that it can do a very great deal besides travel quickly; in fact, it looks as if "Bea" has a superb mount for displaying his renowned aerobatic prowess.

The Duke watched the display—mostly along the Fylde coast—from the edge of the runway, where he stayed ten minutes. The Canberra B.8 was also demonstrated.

The Royal party toured many other factories of the English Electric Group, including the Napier factory at Netherton, Liverpool, from which many Avons are flowing, and where various gas turbines, including the Eland and Oryx, are going into production. His Royal Highness went on to the Napier high-altitude gas-turbine test station at East Lancashire Road before returning to London in a Viking of the Queen's Flight.

On the previous day the Duke had visited the Fulmer Research Institute near Slough, where he inspected the new engineering wing. The Institute, which undertakes research—primarily metallurgical—for industry, was established eight years ago by the late Col. W. C. Devereux.

S. of S. Returns

ON November 3rd Lord De L'Isle and Dudley, V.C., secretary of State for Air, arrived back in London after spending 17 days in North America. The chief reason for his visit was stated to be an inspection of Canadian training schools at which NATO students are instructed, and he visited seven of these bases. Discussions were also held with representatives of the Canadian and American Governments and aircraft industries.

The Comets' Future

NEWSPAPER speculation as to the future of the Comet has already begun, though at the time of writing the official inquiry had yet to run its full course. Some of the reports seem to be based on shrewd reasoning, though all are believed to be unofficial.

One source suggests that a number of Comet 2s may be taken over by the R.A.F.—for use perhaps as transports, possibly for training, and for simulating jet bombers in defence exercises. If flown in non-pressurized, or lightly pressurized, form, there seems to be no reason why existing Comets should not be so employed for several thousands of hours.

High-altitude research is another rôle in which the remaining Comet 1s and the Comet 2s, in their present form, might find useful employment. We believe that the Avro Ashtons now used for this purpose are being worked very hard indeed.

For acceptance on commercial operations Comet 2s will require some stiffening, including re-skinning. As "re-offered" to the airlines, a new Comet 2 could undoubtedly embody many other improvements in the light of experience since the design was virtually frozen some three years ago. Thus, the weight penalty of strengthening the pressure cabin and making other desirable modifications could be more than offset by improved specific fuel consumption and increased thrust from the Rolls-Royce Avons. With these and other developments a new Comet 2 might well offer better all-round performance.

Clearly, de Havillands must now be faced with the need to decide on the future of the Comet 2s already built or lying partially completed at Hatfield, Belfast and Chester. Several factors will influence this decision: B.O.A.C.'s policy on Comet 2 operations; the possibility of a number of aircraft being adopted by the Ministry of Supply or R.A.F.; and the cost, in time and money, of embodying all the improvements required as a result of the Elba-Naples inquiry.

The Comet 3 is in a different category since only the prototype has been built, and the cost of incorporating modifications and improvements in production aircraft should not be prohibitive.

Anglo-American Boeing?

IMMEDIATELY upon returning from a sales-prospecting tour of Europe and other areas, Mr. Ralph P. Bell, the Boeing sales director, announced that a sizeable market existed for production versions of the Boeing 707 Jet Stratoliner powered with British engines. Design studies are known to have been prepared for the 707 with Rolls-Royce Conway and Bristol Olympus engines, both of which are fully equal in power and efficiency to the Pratt and Whitney JT3L turbojets specified for American 707s.

By choosing British engines, the company consider, a large number of Boeings might be sold to operators who would not otherwise consider such a purchase, either owing to the lack of dollars or on account of the undesirability of operating relatively new, and complex, engines many thousands of miles from the manufacturer's factory.

RB-57 Canberras in Europe

THE first of the Martin-built RB-57 Canberras to reach Europe was recently flown *via* Labrador and Iceland to Wiesbaden in Germany. Shortly afterwards it made its first public appearance at Bitburg A.F.B. during the A.A.F.C.E. reconnaissance conference (described on page 700).

The RB-57 is the first of two completely Americanized versions of the Canberra and can be used for either P.R. or bombing work. With an all-up weight of about 50,000 lb, it is powered by two Wright J65 Sapphires and incorporates Martin's own revolving bomb door. The internal bomb load can be supplemented by four napalm tanks and eight 5in rockets carried on pylons under the wings; jettisonable tip-tanks can also be accommodated.

Among the performance figures released by Martins are: sea-level speed in excess of 500 kt, the ability to turn within an average airfield boundary, a range of over 2,000 miles, and an operating altitude of over 45,000ft. The RB-57 carries a crew of two in a tandem cockpit.

Two Tactical Reconnaissance Wings, the 10th at Spangdahlem and the 88th at Sembach, are to convert to RB-57s in the near future. They form part of the 12th U.S.A.F., which is itself part of NATO's 4th A.T.A.F.

Migs Destroy RB-29

ANOTHER air shooting incident off Northern Japan occurred last Sunday, November 7th. This time the American aircraft involved was an RB-29 of the 91st Strategic Reconnaissance Squadron, based on Yekata, Hokkaido. Said by the State Department to have been on a routine photographic reconnaissance flight (the majority of the remaining B-29s, some hundreds in all, are now assigned to such duties), the aircraft was attacked at 11,000ft by two Migs. The crew of 12 baled out over the sea, and ten of them were rescued. The RB-29, on fire, glided to Nemuro, a port in north-east Japan, where it struck

LEVITATION—TRANSLATION: On November 5th, Convair test-pilot J. F. "Skeets" Coleman made the first transition from vertical to horizontal flight—and, as shown, back again—with the XFY-1 "pogo-stick" prototype, at Brown Naval Auxiliary Air Station, San Diego.

***LONG-RANGE MIGS?** Lately received from Germany, this picture is said to show two Mig-15s with under-wing drop-tanks. Such sights are reported to be familiar to the citizens of Berlin—especially those of the northern parts.*

a house. The State Department's spokesman said that the Mig opened fire when the RB-29 was one mile east of Nosappu Point, having just made a 180-deg turn to head west. It did not at any time cross the line between Hokkaido and the Habomai Islands (which the Russians occupied after the war, claiming them as part of the Kuriles). A protest was sent to Moscow, while the Soviet Government alleged that the aircraft had infringed their territory.

There were unconfirmed reports that an American jet fighter crashed in the same area shortly after the RB-29.

The last incident of this kind occurred over the Sea of Japan on September 4th, when a U.S. Navy Neptune was shot down by two fighters, one of the crew of ten losing his life as a result of the attack. The news of the latest incident came only three days after the announcement that the Chinese Government had accepted Britain's claim for £367,000 for the loss of the Cathay Pacific Airways DC-4 shot down near Hainan Island on July 23rd. In this attack, ten of the 17 occupants lost their lives.

Fighter Fatalities

ON November 4th the second Convair YF2Y-1 Sea Dart hydro-ski fighter prototype disintegrated while it was making a high-speed run at 500 ft above San Diego Bay, California. The delta-winged aircraft had been airborne for only about one minute; it burst into flames as it began to make a fly-past and the heat blast which accompanied the break-up is reported to have been so intense that a watching crowd ducked to escape it. The pilot, Charles E. Richbourg, was taken alive from the water but died shortly after.

On the same day a Swedish Saab A 32 Lansen (of the type illustrated on pp. 704-5 of this issue) met with a fatal accident during a test flight over Central Sweden. The pilot, who was killed outright, was the well-known Capt. Bengt Fryklund, who won the McKenna Trophy as top pupil on last year's E.T.P.S. course at Farnborough. Thus two brilliant winners of this trophy have recently lost their lives, the other being F/L. R. J. Ross, who was reported missing in a production Javelin on October 22nd.

Merchant Airmen at the Cenotaph

FOR the first time the Merchant Air Service was represented side by side with the other Services at the Remembrance Ceremony at the Cenotaph last Sunday. A composite aircrew composed of representatives of B.O.A.C. and B.E.A. and headed by Capt. O. P. Jones, C.V.O., C.B.E., R.A.F.V.R., marched in the parade from Wellington Barracks to the Cenotaph, where Capt. Jones laid a wreath after the service. A B.E.A. Viscount pilot—Capt. E. V. Waites—represented the Merchant Air Service at the Abbey service.

Next year, it is hoped, aircrews of the independent companies will also be represented. For some time past the Air League of the British Empire has been urging the Minister of Transport and Civil Aviation to ensure that the Merchant Air Service is given official recognition equivalent to that enjoyed by the Merchant Navy and the Fishing Fleet; these organizations have a recognized place on great public occasions and their officers share with the fighting Services eligibility for the award of certain decorations.

Aeronautical History in Yorkshire

AN outstanding Royal Aeronautical Society lecture, the inaugural Cayley Memorial Lecture—devoted to the life and work of the great pioneer it commemorates—was presented by Captain J. Laurence Pritchard in Hull on November 4th. The author's own summary, specially written for *Flight*, appears on pages 701-703.

In the absence of Sir Sydney Camm, the president of the Society, Mr. A. G. Elliott, joint managing director and chief engineer of Rolls-Royce, Ltd., presided. The work of Sir George Cayley, a Yorkshireman sometimes referred to as "the father of British Aeronautics," was a happy choice of subject for the 25th anniversary of the Brough branch, which was responsible for the presentation of this main lecture. Incidentally, the first of the autonomous branches of the R.Ae.S. was founded in Coventry in 1925.

Introducing Captain Pritchard, Mr. Elliott spoke briefly of his training and experience and especially of his services to aviation while secretary of the R.Ae.S. until his retirement three years ago. The lecturer himself commented on and read abstracts from his paper. Mr. Robert Blackburn, chairman of Blackburn and General Aircraft, Ltd., then proposed a vote of thanks and presented him with a silver salver. Additional thanks and a further tribute were pronounced by Mr. N. E. Rowe, Blackburn's technical director, who is also chairman of the R.Ae.S. Branches Committee and president-elect of the main Society. Mr. Robert Blackburn, Mr. Eric Turner, Mr. Rowe, Mr. Pretty and other members of the Blackburn staff later entertained the lecturer and visitors to dinner at the Royal Station Hotel in Hull.

Transatlantic Solo No. 5

MAX CONRAD, a 50-year-old American with some 30,000 hours' flying behind him, made his fifth solo crossing of the Atlantic between November 6th and 7th. This time he was flying a red-and-cream Piper Apache (two 150 h.p. Lycoming) which he delivered to a European purchaser, M. Robert Goemas.

Mr. Conrad spent the whole of November 4th and 5th in a hangar at Idlewild Airport, New York, supervising the fitting of extra tanks to give an estimated endurance of 26 hr; he took off at 4.26 p.m. G.M.T. on November 6th. Weather was fair to begin with but deteriorated, and icing forced him down to sea level for long periods. He was out of radio contact from midnight until 10.30 the next morning, when he passed Shannon airport. At 3.30 p.m. he landed at Toussus-le-Noble, Paris, where he was welcomed by large crowds. His sole diet had consisted of a bottle of squash, petrol having leaked from a supplementary tank onto his only solid food—a packet of cream biscuits.

The Apache is the first to be seen in Europe; it is a four-seater capable of cruising at better than 170 m.p.h., and selling for a basic price of $32,500 (£13,100).

We published a photograph of Mr. Conrad in *Flight* of June 27th, 1952, when we recorded a long solo tour of Europe which he made in a Piper Pacer. Incidentally, he has ten children.

***LEAVING BY VISCOUNT** for Copenhagen, after a visit to Vickers-Armstrongs, are (carrying hats) Mr. A. J. Woodley, president of Pacific Northern Airlines Inc., and Mr. R. Kinsey, his assistant. On the steps is Mr. R. C. Handasyde, V-A sales manager, and between the visitors is Capt. J. W. G. James, B.E.A. flight operations director. P.N.A. operate in Alaska and from Alaska to U.S.A.; they employ DC-4s and 3s and a Lockheed 12. Now it is rumoured that they may purchase Viscounts—perhaps as many as ten.*

FROM ALL QUARTERS . . .

Supersonic Minister

THE following is a translation—which closely maintains the spirit of the original—of an account published in the French journal *Figaro* on October 27th:—

"Yesterday morning, at 11.0 a.m., in excellent weather, M. Diomede Catroux, Air Minister, went on board the prototype 'Mystère IV N' fitted with an Avon jet engine with reheat, at the present time on test at the Flight Testing Centre at Bretigny. The aircraft was piloted by the test pilot Jean Lanvario.

"After a brief medical examination, the Minister—considered fit—and dressed in a blue overall, fastened his parachute, safety-belt, helmet and oxygen mask then, the jet engine started, raised his thumb with a confident "O.K." sign.

"From one of the rooms in the control tower of the Flight Testing Centre I was then able to follow all the events of the flight, the climb to 43,000ft in 7 minutes, the passing over Orleans after 10 minutes' flight, then the dive during 10,000ft only, reaching Mach 1, then Mach 1.07, then 1.15 finally levelling-off under 2g (that is to say that the weights of the aviators on their seats were then double). The test pilot Muselli conversed with Lanvario, whilst M. Jacques Dassault, son of the constructor, recorded the time. After exceeding the sound-barrier, Lanvario made a successful reheat test and improved it with a few rolls.

"Twenty-five minutes after its take-off, the Mystère IV N came down on the runway at Bretigny and the general engineer Bonte first of all offered his guest some champagne, then the badge of the Flight Testing Centre. M. Catroux, visibly moved, thanked his host warmly; and to finish on a note of gaiety, M. Dassault named the Minister 'High Mach' in passing a fine green and white tie round his neck.

"It only remained for the new member to be photographed, surrounded by some 'High Machs' present, Lanvario, Madame Auriol, Muselli and Major Guillaume.

Tribute to Sir Winston

MOST of our readers will already have heard of the proposal to mark Sir Winston Churchill's 80th birthday, which falls on November 30th, by a presentation—the result of public subscription—which will make known to the Prime Minister the esteem and affection in which he is held throughout the world. Nevertheless, we gladly accord this space to a reminder on the subject.

When the fund (which is essentially of a non-party character) was launched Sir Winston indicated that he might eventually suggest that the presentation should take the form of some national or international, social or humane endowment; but, say the organizers, it is the overwhelming opinion of those who are contributing (many donations have already been received) that the amount collected should take the form of a personal birthday gift for Sir Winston to employ as he alone may wish.

Contributions—and even the smallest are welcome—should be addressed to the Rt. Hon. Lord Moynihan, Hon. Treasurer, Sir Winston Churchill 80th Birthday Presentation Fund, 156 Charing Cross Road, London, W.C.2. Cheques should be made payable to "Churchill Presentation Fund."

CHIPMUNK OVER THE ANDES

DURING a recent 1,500-mile tour of South America, G/C. A. MacDougall, a de Havilland area representative, successfully crossed the Andes in a Chipmunk. The flight was made from Mendoza in Argentina to Santiago in Chile, *via* the Christo Divide and Los Angeles, where the neighbouring *massif* of Aconcagua rises to a height of nearly 23,000ft. Mendoza itself is 2,400ft a.s.l., and the mountain range rises thence, abruptly, to 11,000ft. There are two valleys to follow, that of the Mendoza river running eastwards, and the Uspallata Pass, which it joins, running south-eastwards. It is the junction of these two valleys which is the worst point, because of often unpredictable high winds and violent turbulence. There are also areas of very strong down-draughts.

G/C. MacDougall made his first attempt when the winds were forecast light. To save time and fuel, he climbed on track along the Mendoza river at full power until, at 10,000ft in the valley, he met severe turbulence; but he was able to climb to 13,000ft by the time he reached the junction with the Uspallata valley. Here the trouble began. Turning westwards to enter the main pass, he met severe turbulence and a "bump" which first carried him to 15,000ft, and then dropped him 3,000ft in about 15 seconds. The A.S.I. was showing anything from 40 to 130 kt, the temperature was −50 deg C, and the wind westerly 50 kt. After further climbing, laboriously to 14,000ft, he realized that he had made good only 25 miles in 40 minutes (the last five miles had taken 20 minutes) and that he was now making no headway at all.

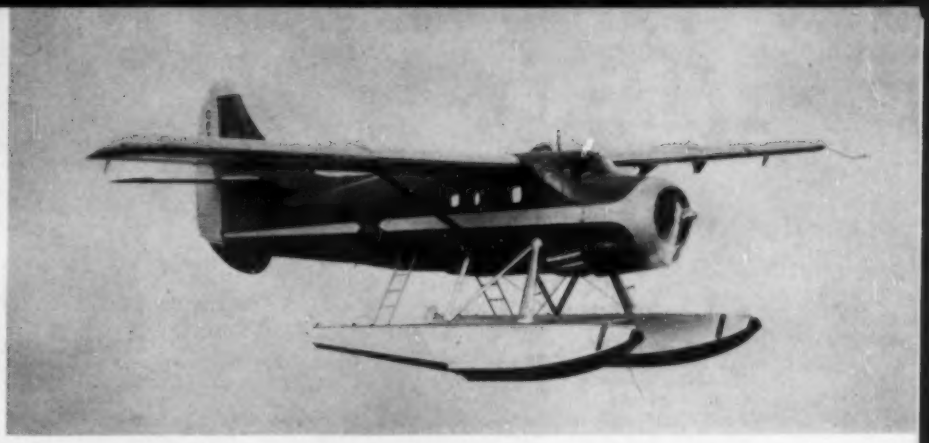
He therefore decided to try a 14,000ft pass to the south over the Divide, between the Maipu river and the Rio Tunuyan. But here, too, turbulence and down-draughts, headwinds and the lack of an escape valley defeated all efforts to cross; so a return was made to Mendoza.

Later the same day the pilot took off again, but this time he climbed to 16,000ft over Mendoza, shaped a northerly course for the Uspallata Pass and reached the main range without undue loss of height. Keeping as much as possible to the northern side of the valley, he made 17,000ft with a reasonable ground speed. Over the critical sector from the confluence of the valleys to the point known as Las Cuevas—about 40 miles—the wind reached its maximum strength of 35 to 40 kt, after which it fell to about 20 kt. Las Cuevas was passed at 19,200ft, with an outside temperature of −12 deg C, and 15 minutes later a gradual descent was begun, taking advantage of improved wind conditions. The weather was clear and turbulence moderate.

G/C. MacDougall crossed the Divide two hours after leaving Mendoza and sighted the central plain of Chile shortly afterwards. Some 20 minutes later he reached Los Cerrillos airport, Santiago. Incidentally, the Gipsy Major's fuel consumption over the whole route from Montevideo averaged 6.8 gal/hr and was as low as 5.8 gal/hr above 13,000ft. It gave no trouble at all during the Andes crossing.

The Andes seen from the Chipmunk at 18,500ft and (right) G/C. MacDougall in the cockpit. The name "Urutaú" means, in the language of the Paraguayan Indians, "Old bird of the woods."

HERE AND THERE



MOUNTIES' NEW MOUNT: This smart D.H.C. Otter has just been delivered to the Royal Canadian Mounted Police. They already operate four Beavers in eight of Canada's provinces.

Royal Lecturer to R.Ae.S.

THE tenth British Commonwealth and Empire Lecture of the Royal Aeronautical Society, on December 16th, is to be delivered by the Duke of Edinburgh. His Royal Highness's subject has not been announced at the time of our going to press, but lectures in this series customarily deal with the wider aspects of civil aviation, particularly in relation to the Commonwealth.

Air Force for Jordan

JORDAN RADIO reported last week that a speech from the throne read by Premier Tawfiq Abu Al-Huda at the opening of Parliament in Amman, and dealing with internal and external affairs, contained a passage which made it clear that a Jordan air force is to be set up. A radio commentator added that plans are now being prepared and that "friendly foreign specialists" will be invited to help in the organization.

The Lost R7V-1

MORE than 200 aircraft and 25 ships took part in the search for the U.S. Navy R7V-1 Super Constellation which was lost over the Atlantic on October 30th. On November 4th the U.S. Navy announced that hope of finding survivors had been abandoned.

New Experience

SON of Sir Richard Fairey, and a director and general manager of the Fairey Aviation Co., Mr. Richard Fairey is taking a helicopter course at the Westland school. Last week he went solo in an S-51 after 1 hr 40 min. He has flown some 4,000 hours on fixed-wing aircraft. During the war, in which he was a ferry pilot, he lost both legs when a ship in which he was travelling was torpedoed.

Ypenburg Next Year

THE Royal Netherlands Aero Club has decided to take advantage of the extensions to Ypenburg airfield, near the Hague, to stage a major air display on Whit Monday, May 30th, 1955. It is hoped to gain the co-operation of the aircraft industries and air forces of Western Europe and America in order to produce "a memorable aeronautical event."

Civic Honour

MR. G. H. DOWTY, founder of the Dowty Group of Companies is to receive the honorary freedom of the borough of Cheltenham. Announcing Mr. Dowty's acceptance of the invitation, the Mayor said recently that the council had watched with interest the growth of the undertaking to international proportions and the contribution it had made to Cheltenham's industrial prosperity.

High Payloads

RECORDING the success of the claim made recently by B.O.A.C. York freighter pilots for additional payment to cover the unpleasant aspects of carrying livestock freight, *The Log* (journal of the British Airline Pilots' Association) says that "by its very nature alone the claim attracted a good deal of Press comment." Under the heading "Gamey Airmen get Barnyard Boost," one American paper reported that "A sympathetic wage tribunal awarded 20 airplane pilots a pay rise because, to put it frankly, they stink." In airline circles, incidentally, the Industrial Court's award of 7s per flying hour is frequently referred to as "monkey money."

Airline Treatise Competition

SABENA announce that their international prize of 75,000 Belgian francs (about £535), established in 1953 to mark the 30th anniversary of the airline's foundation, will be awarded in 1955 for the best study on "Aviation and Social Geography." The competition is open to nationals, under 30 years of age on May 23rd, 1955, of all the 32 countries served by Sabena. Details may be obtained from any of the company's offices.

Large Airliner Operations

IN last week's article "Long-range Battle," dealing with immediate operational prospects for large airliners, a printer's omission of the word "not," in the resetting of a line, gave a contrary meaning to a sentence concerning the Bristol Britannia and the Douglas DC-7. As the subsequent context suggested, this particular passage should have read: "On the face of things it does not appear that any DC-7 development could match any Britannia with which it might be contemporary, but these new Douglases are worth studying."

LORD SWINTON, Secretary of State for Commonwealth Relations, visiting the new Bristol subsidiary in Canada, MacDonald Bros. Aircraft, was greeted by Sir Reginald Verdon Smith, Bristol's joint managing director, who was also then in Canada.

"MAD-BIRD" is the U.S. Navy's nickname for the Lockheed P2V-7 Neptune with magnetic airborne detector (hence the "M.A.D.") equipment carried in their extended tail. Its purpose is submarine hunting.

The 2nd A.T.A.F. contribution to the A.A.F.C.E. reconnaissance conference included the two Meteor F.R.9s and an RF-84 seen here under the wing of a Bomber Command Canberra P.R.3 at Bitburg.

RECCE CONFERENCE

Allied Air Forces Central Europe Discuss and Display New Methods

THE second annual A.A.F.C.E. reconnaissance conference was held at Spangdahlem, in the American Zone of Germany, during the first four days of last week. It is the aim of this conference to assemble air-reconnaissance specialists from the NATO nations so that opinions and experience can be exchanged and common problems discussed. Particularly in the type of warfare which must be expected in a future major conflict, reconnaissance would be all-important—not only the securing of aerial photographs, but their processing, interpretation and distribution in numbers. It is obviously desirable to standardize both the equipment and the procedure for producing photographic intelligence in the various NATO air forces, and an important object of the annual conference is to work towards this goal.

As explained by General Dudley Hale (Assistant Chief of the U.S. Air Staff) prior to the opening of the conference, the nature of air reconnaissance work is complicated by the number of nations taking part. As important as the standardization of equipment is the flexibility of the forces engaged. P.R. aircraft from one country should be able to land in another country and receive full servicing facilities, as well as having their films processed on the spot. General Hale said that fast and manœuvrable aircraft had been recommended for all types of reconnaissance, but that, so far, none of the many types adapted for P.R. work had proved ideal. The principal shortage, however, was in P.R. equipment and a great deal of work was being devoted to remedying this.

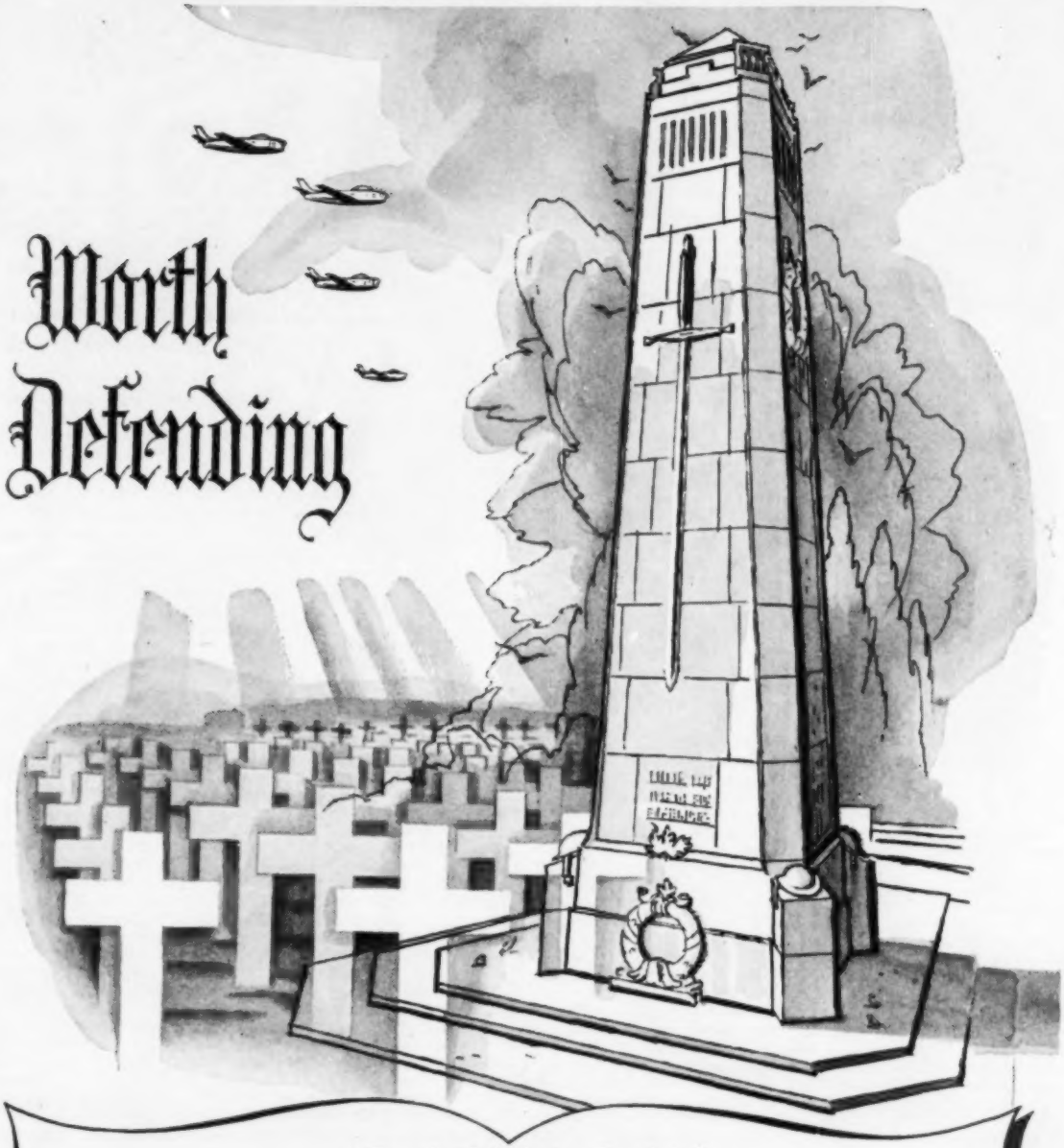
The conference itself was held at Spangdahlem, but, because of an accident there the week before, the static and flying aircraft display was held at Bitburg, nearby. It is noteworthy that the largest contribution of both aircraft and equipment came from 2nd A.T.A.F., and consisted of the large mobile field processing and interpreting unit from 2nd T.A.F., two Meteor F.R.9s, two P.R.10s, an RF-84 of the Royal Netherlands Air Force, and a Canberra P.R.3 from England. The Meteor F.R.9s carry three F.95 cameras working at 4 to 8 frames/sec. A later camera, the F.97, was also shown; it has twin lenses and an oscillating shutter and is fitted with a photo-flash cartridge for night photography. From 4th A.T.A.F., the French Air Force showed the first RF-84G Thunderjet ever to be converted to this rôle; and, finally, there was the latest American arrival in Europe, the Martin RB-57 Canberra, with which two Tactical Reconnaissance Wings in Germany are to be equipped.

One of the key elements in photographic reconnaissance is processing and interpretation. The conference exhibition made it clear that British and French developments in this sphere were well ahead of corresponding U.S.A.F. equipment. Particularly significant is the British-developed, 2nd A.T.A.F. Mobile Field Photographic Section mentioned above, and described in some detail in *Flight's* report of Exercise Battle Royal (October 8th, 1954). This unit is capable of providing initial interpretation in 35 minutes and full distribution within six hours. Similar units, from both the U.S.A.F. and the French Air Force, were on show at Spangdahlem. The Quonset hut is the basis of the American processing unit, which can be loaded either into three 2½-ton trucks or one Fairchild C-119 Boxcar. It can produce 400 prints an hour and requires 13 men to operate it. The French first-phase processing and interpretation unit comprises three vehicles. These can be joined by light-proof canvas coverings and have their own built-in chemical-storage tanks and mixers. The standard crew is seven men.

A high-capacity unit is now being developed for U.S.A.F. and work towards standardization of both NATO equipment and procedure will continue at full speed. The ultimate development of air reconnaissance, however, was foreshadowed in an American statement to the effect that there might yet emerge a reconnaissance aircraft with a television camera which transmitted its pictures direct to a processing laboratory following on behind in a large aircraft. It was not certain whether such a system could in fact be achieved, but it was thought that this would provide the quickest interpretation and reproduction facilities.

The latest P.R. equipment to reach A.A.F.C.E. is the Martin-built RB-57 Canberra (left, above). Exhibits in the static display at Spangdahlem included the F.95 camera, here being inspected by A. Cdre. H. P. Pearson, A. Cdre. P. G. Wykeham-Barnes (conference chairman), Major D. D. Hale, Col. B. O'Neil and S/L. F. H. P. Lewer.

Worth Defending



"To you from failing hands we throw the torch,
Be yours to hold it high:
If ye break faith with us who die
We shall not sleep though poppies grow
In Flanders fields."

And yet, when the parade is over and the last bugle note fades, it is so easy to "break faith" by being lulled into a sense of "*nothing will happen here*" . . . to let victory and freedom go by default.

"Hold high the torch" — but will we do it? We will if we respect the sacrifices of our soldiers, sailors and airmen through the great struggles in the past. Think it over in your mind . . . what they died for is worth defending *now!*

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A page from
THE ESSO HISTOIRE OF AERIAL LOCOMOTION
Adapted from the French de P. Crochet-Damais. Illustrated par Philippe Féty avec permission.

MONTGOLFIER AND THE PETTICOAT

ACCORDING to the memoirs of the Baron de Gérando, Montgolfier is supposed to have first thought of the possibilities of balloon travel while sitting before the fire and the family wash.

It appears that Montgolfier did most of his thinking in the chimney corner of his home at Avignon, and on the occasion we are now discussing his mind was exercised by the siege of Gibraltar and a private wish to witness exciting events in a spot that could be visited neither by land nor sea! Frustration!

And then the incredible happened — before his very eyes! Suddenly, his wife's petticoat, which had been put to dry in a corner of the hearth, rose slowly to the ceiling. Montgolfier was overcome with happiness. He realized that the pretty garment had taken off, as it were, under the impulse of a pocket of warm air, and he realized, too, that in this phenomenon lay the answer to his hopes of visiting Gibraltar.

He called for taffeta and thread, fashioned a small balloon, and made it rise from the hearth. The wonderment of the household was extreme, and Madame Montgolfier, who had lost a petticoat in the experiment, was so moved that she forgot to scold her husband. But this was, of course, long before the days of petticoat government.

Today genius gets results by remembering that it pays to say

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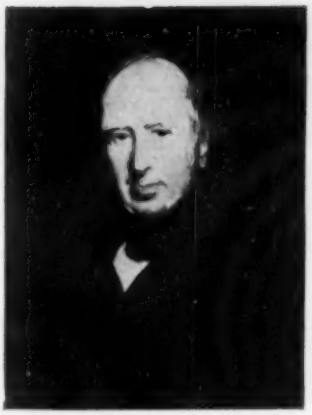
SIR GEORGE CAYLEY

The Man: His Work

By J. LAURENCE PRITCHARD, C.B.E., Hon. F.R.Ae.S.



THE First Cayley Memorial Lecture was read before the Brough Branch of the Royal Aeronautical Society on Thursday of last week, November 4th. The full lecture, which would take up over twenty pages of "Flight," is here summarized for us by the lecturer. As most of our readers will know, Capt. Pritchard was for many years—from 1925 to 1951—secretary of the R.Ae.S.

FEW men have written a birthday ode to their wife on her eightieth birthday. Sir George Cayley married the beautiful daughter of his mathematical tutor in 1795, and lived happily ever afterwards. His birthday ode, after 58 years of married life, began:—

"Full many a pleasing, many an anxious thought
This lengthened day of eighty years has brought."

You may well ask: "What has this to do with his aeronautical fame?" This paper is an assessment of the man as well as his work, for on both must his place in history rest. How misjudged would Nelson have been if Lady Hamilton had never been taken off the secret list, or Napoleon if Josephine had been put on it?

Sir George Cayley succeeded to his father's estates in 1792, when he was only nineteen. He early showed his interest in scientific and engineering pursuits; but, as the lord of the Manor and a political and social figure in Yorkshire, he was not able to devote anything like the time he would have liked to his ideas. The chief of these were concerned with the problem of flying, about which nothing was known except in relation to balloons.

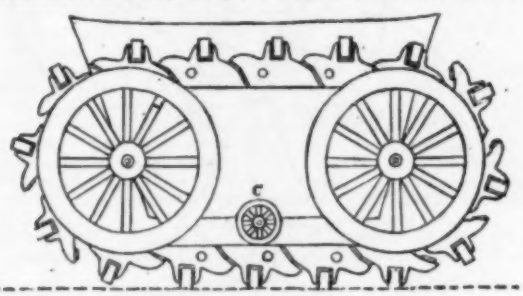
Three times in his long life he tried to found an aeronautical society, the first time in 1816 and the last in 1843, when he wrote: "I think it is a national disgrace . . . not to realize by public subscriptions the proper scientific experiments . . . which would secure to this country the glory of being the first to establish the dry navigation of the universal ocean of the terrestial atmosphere."

He was a founder-member of two important societies for promoting science and an interest in it, the Yorkshire Philosophical Society and the Scarborough Philosophical Society. Through the former, Cayley played his part in helping to found, in 1831, the British Association for the Advancement of Science. He remained a member of it during his lifetime.

Cayley's interests were wide. In the paper a detailed account is given of his many non-aeronautical activities. He was the inventor of the hot-air engine, which attracted the attention of leading engineers for half a century; and of the caterpillar tractor. "This invention," he wrote of the latter in 1825, "which may be called the universal railway, is for the purpose of forming locomotive vehicles by which the impediments and resistances of every sort of road, land, morass or water will be obviated or overcome."

The coming of the railway, and the early disasters, aroused him to publish a number of papers on safety devices and improvements in construction. He was strongly of the opinion that the human factor should be eliminated as far as possible, and he drafted out an automatic block system of signal control on the railways, with constructional diagrams, and the further suggestion that "in case of fogs a bell should likewise be arranged as to ring on the train passing any post showing the red signal." Perhaps the situation then, as far as the public was concerned,

Fig. 1. This illustration, which appeared on the first page of the "Mechanics' Magazine" for January 28th, 1826, showed Cayley's "patent universal railway" design, forerunner of the caterpillar tractor.



CAYLEY WAS THE FIRST MAN TO

(1) Clarify the confusion of ideas about mechanical flight, and to lay down the principles of heavier-than-air flight. (2) Carry out experiments in aerodynamic research, for flying purposes, on the pressure on surfaces at various angles of incidence. (3) Use models for flying research. (4) Draw attention to the importance of streamlining and to outline the body of least resistance. (5) Show and discuss the movement of the centre of pressure of a surface in an air stream. (6) Discuss the problem of stability of an aeroplane, and to indicate methods to obtain stability. (7) Draw attention to the effects of the dihedral angle for wings, and of a movable tail plane and rudder. (8) Draw attention to the great importance of weight control. (9) Design a light aeroplane wheel. (10) Build a man-carrying glider. (11) Point out that curved surfaces had a better lift than plane surfaces, and that there existed a region of "vacuity" on the top surface. (12) Suggest the "internal explosion" (i.e. combustion) engine for aircraft. (13) Suggest jet reaction for propelling and steering air vessels. (14) Suggest the convertiplane, i.e. the combination of the fixed wing surface and vertical lift surfaces. (15) Suggest water recovery for airships. (16) Draw the attention of the importance of the power/weight ratio, and of finding a light prime mover. (17) Invent the expansion air engine. (18) Invent the caterpillar tractor.

can be realized when Cayley wrote: "It is necessary to make it a positive law, that the up trains shall always keep to one set of rails, and the down trains to the other."

For over thirty years Cayley was the chairman, under the Muston Drainage Act, for the effective drainage of frequently flooded land in Yorkshire; he was the first to start the allotment system on his own estates, an example widely followed for many years. He directed his attention to optics for testing the purity of water, a method used successfully in the investigation of the waters of the Thames; and published a paper for the acoustical design of a new Covent Garden Theatre. In 1804 he carried out experiments with six-pounder cannon shot. "My object at the time was to ascertain whether, by obviating as much as possible the resistance of the air, the range of cannon shot might be increased." One of the shells he designed was almost a replica of the bomb shapes with guiding fins used in the early stages of the 1939-45 war.

It was in 1804 that Cayley began to write his famous paper on Aerial Navigation, a work he was not able to complete for four years. This paper is published in full, for the first time since its original publication, in the appendix to the lecture.

One hundred and fifty years after Cayley began his essay, von Karman wrote in his book *Aerodynamics* (published this year), "The idea that sustentation can be accomplished by moving inclined surfaces in the flight direction, provided we have mechanical power to compensate for the air resistance, was probably clearly defined for the first time by an Englishman, Sir George Cayley, in his papers published in 1809-10 on aerial navigation . . . in his paper he clearly defined and separated the problem of sustentation, or in modern scientific language the problem of lift, from the problem of drag."

"Lightness is of so much value," declared Cayley in his paper, after rejecting the steam engine as being too heavy for his ideas, "that it is proper to notice the probability that exists of using the expansion of air, by the sudden combustion of inflammable powders or fluids, with great advantage. . . . Probably a much cheaper engine of this sort might be produced by a gas-tight apparatus and by firing the inflammable air with a due proportion of common air under a piston."

It was after a brief but significant discussion on the forces on a bird in gliding flight that Cayley made the statement: "The whole problem is confined within these limits—To make a surface support a given weight by the application of power to the resistance of the air."

This paper provided the first clarification of ideas about mechanical flight and was the first to lay down the main principles.

The resistance of a plane in a moving stream of air, at various angles of incidence, was unknown. In his paper Cayley refers to "many carefully repeated experiments" to obtain the pressures on a plane, but it was not until the discovery of his notebook in 1933 that it was known how astonishing these experiments were. Cayley records that they were made with a home-made whirling arm apparatus, to find the pressure on a flat plate, one foot square, at angles of incidence from 3 deg to 18 deg, in 3 deg steps. He was well aware of the difficulties of obtaining exact results, and carried out further tests, using a

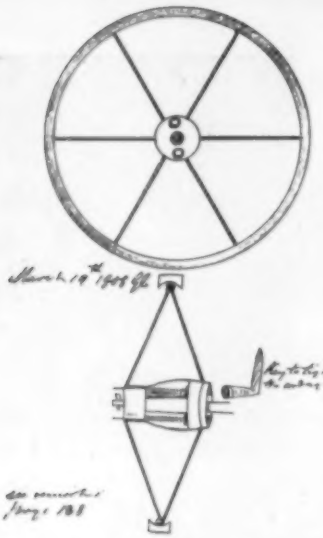
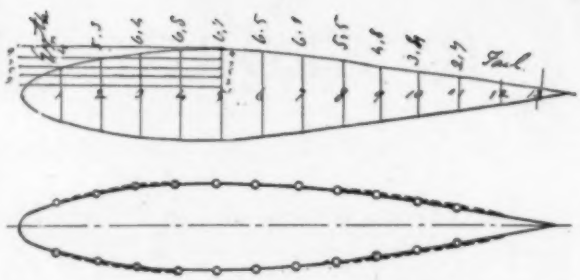


Fig. 2 (left) Cayley's light wheel for aeroplane undercarriages, the forerunner of the bicycle wire wheel.

Fig. 3 (right) Solid of least resistance — a sketch by Cayley—with, below, N.A.C.A. aerofoil 63A016-LB N-0016.



SIR GEORGE CAYLEY . . .

model glider, with an adjustable tailplane and a movable centre of gravity, to test his results.*

In this paper Cayley briefly touches upon the helicopter, the principle of which he demonstrates with a model using two sets of contra-rotating airscrews made from birds' feathers. "For the mere purpose of ascent this is perhaps the best apparatus," he declares, "but speed is the great object of this invention, and this requires a different structure."

He discusses the problem of the lateral and longitudinal stability of a fixed-wing machine and "aided by a remarkable circumstance that experiment alone could point out," shows that at very acute angles of incidence the centre of pressure moves considerably in front of the centre of gravity of a wing. This was the first statement made of the centre-of-pressure movement.

Light construction, light engines, and minimum forward resistance were the key features of all Cayley's ideas about heavier-than-air craft.

"In thinking of how to construct the lightest possible wheel for aerial navigation cars," he wrote in 1808, "an entirely new mode of manufacturing this most useful part of locomotive machines occurred to me—*vide*, to do away with wooden spokes altogether, and refer the whole firmness of the wheel to the strength of the rim only, by the intervention of tight cording." In a later paper he pointed out that the wheel was an incumbrance during flight, a cogent reason why it should be as light as possible.

Cayley's next papers appeared in the famous *Phil Mag.* in 1816. In them he discussed airships: "A globe is by no means the best shape for obviating resistance; a greater extension in the line of its path, with a corresponding diminution in the section perpendicular to it, may be adopted with great advantage."

In his notebook he made a sketch of what he called "the solid of least resistance" based on the measurements of the trout. Von Karman, in his *Aerodynamics*, draws attention to the astonishing fact that Cayley's outline "almost exactly coincides with certain low-drag airfoil sections." The figure shows Cayley's sketch and his points superimposed upon the N.A.C.A. aerofoil section 63A016-LB N-0016.

In his paper of May 1816 Cayley proposed an airship 432ft in length with a total lift of 163,000 lb. He allowed a weight of 160 lb/h.p./hr for a steam engine with coal and water, "and as the water is a considerable part of the whole, and can be recovered by permitting steam to pass within the double coats of the balloon and to be thus exposed to so extensive a cooling surface it is probable that 200 lb per horsepower will be more than sufficient for working twelve hours without any further supply of water or fuel."

This was a remarkable suggestion for water recovery in airships. He had suggested an inner skin of oiled silk to conserve the hydrogen and lessen the danger from accidental damage to the outside skin. Cayley calculated the speed at 20 m.p.h. and the range in calm air, carrying 50 men, to be 960 miles.

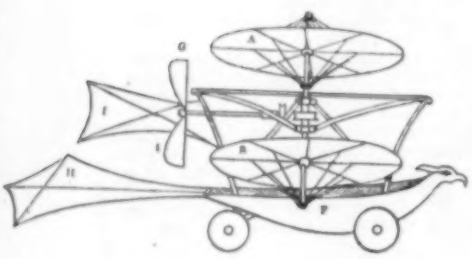
In his 1837 paper in the *Mechanics Magazine* he discussed other means of propelling an airship. One of these is of present-day interest: "Communicating centrifugal force to air by means of a hollow drum and fans by the steam engine is another means of getting a propelling power conveniently applicable in every direction that may be required; for by having a movable mouthpiece, from which the air escapes, the re-action will always be in the opposite direction."

Shades of the turbojet!

One of his more remarkable papers appeared in 1843. In it Cayley outlined what would now be known as the convertiplane. There were revolving blades for the take-off and airscrews for horizontal flight: "The first may be termed the elevating fliers, to distinguish them from the two smaller ones, set at a very different angle with their axis, and used for propelling the machine, when the others are stationary; both sets will be put

**Since this lecture was prepared, these experiments have been analysed by A. H. Yates ("Flight," October 22nd, 1954). He draws attention to the surprisingly good agreement of Cayley's results with modern theory as given by Flax and Lawrence at the 1951 Anglo-American Conference.*

Fig. 4. Sir George Cayley's designs for an "aerial carriage."



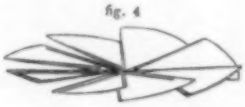


fig. 4

Mechanics' Magazine, 273

MUSEUM, REGISTER, JOURNAL, AND GAZETTE.

No. 1036.] SATURDAY, APRIL 8, 1843. [Price 6d.

Edited, Printed and Published by J. C. Robertson, No. 166, Fleet-street. Dublin.

SIR GEORGE CAYLEY'S AERIAL CARRIAGE.

Fig. 1.

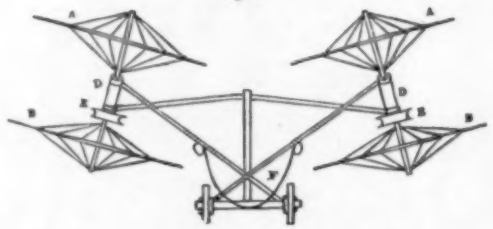
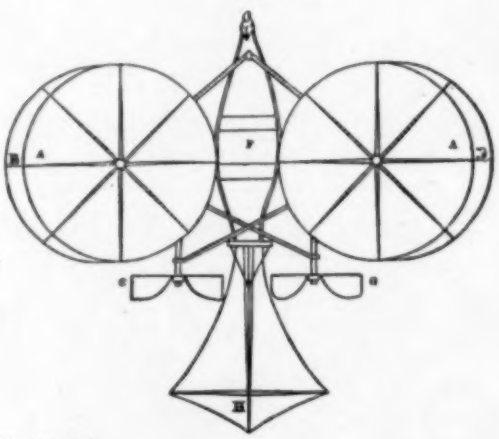


Fig. 2.



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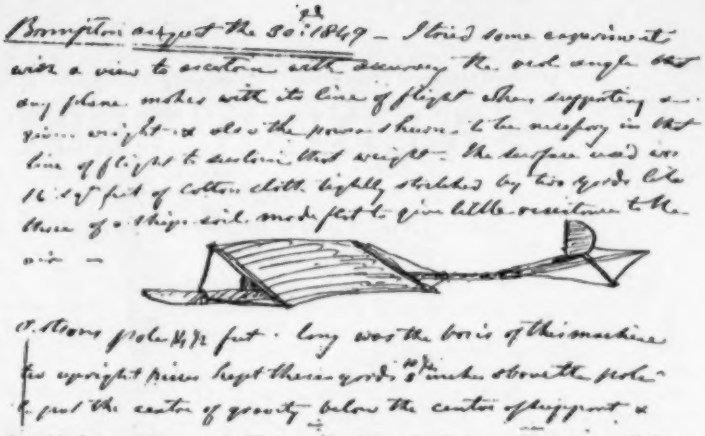

Fig. 5. Part of the inventor's notes for an experimental glider. Passages include:

"I tried some experiment with a view to ascertain with accuracy the real angle that any plane makes with its line of flight when supporting a given weight and also the power shown to be necessary in that line of flight to sustain that weight. The surface used was 16 square feet of cotton cloth tightly stretched by two yards like those of a ship's sail made flat to give little resistance to the air. . . . The velocity varied in some of the flights, but the best average was at the rate of 200 feet in 6 seconds. . . . Hence a velocity of about 33 feet [per second] at an angle of 7° with the line of path . . . sustains on 16 feet, 16 pounds. This agrees precisely with the weight of the crow and his surface of wing."

into action gradually, or in any required degree by friction plates." The contra-rotating "elevating fliers" were arranged to eliminate torque, and set at a dihedral angle for lateral stability. This is Cayley's machine "capable of landing at any place capable of receiving it, and of ascending from that point," and "capable of remaining stationary, or nearly so, in the air," to use his own words.

Cayley's last-but-one contribution to the science of aeronautics was one he wrote in 1853 for the French Aeronautical Society. He was then in his eighty-first year. In it there is a description of experiments to ascertain the weight carried by a surface at a given angle of incidence when gliding. In one of these experiments with a larger glider he writes, "a boy of ten years was floated off the ground for several yards on descending a hill, and also for about the same space by some persons pulling the apparatus against a very slight breeze by a rope." After drawing attention to the difficulties and dangers of starting a glide, Cayley anticipated Lilienthal by proposing an artificial hill to be constructed for gliding experiments. In those carried out at Cayley's home, Brompton Hall, in 1852, Cayley's grand-daughter, who witnessed them, wrote, "The coachman went in the machine and landed on the west side at about the same level. The coachman got himself clear and when the watchers got across he shouted, 'Please, Sir George, I wish to give notice. I was hired to drive, not to fly.' "

In 1855 Cayley wrote his last aeronautical paper, on an "Improved Flying Top," and died at Brompton Hall on December 15th, 1857.

This summary is necessarily inadequate; but, as Cayley's papers are more carefully studied, in the light of the knowledge of the time, I am sure his reputation as "the Father of British Aeronautics" will be enhanced.

He was a member of the Institution of Civil Engineers and regularly attended their meetings when in London. He travelled often on the Continent, and met and was friends with many of the leading scientists there. He was a man of great personal charm, an excellent mechanic, a man of imagination, and one who had the gift of being able to mix with kings and yet not lose the common touch. He was a fierce patriot, and wrote and spoke at length on the necessity of a national defence force. He advocated, indeed, in a long and reasoned pamphlet, the calling up of one-quarter of the available male population for twenty days each year. (He was himself a colonel in the Volunteers.) The words with which he finished his appeal, written in 1807 when there were threats Britain might be invaded by Napoleon, might have been written today:—

"Let us then embrace the opportunity of repose afforded to this country by the present position of continental affairs; and assiduously rear up a bulwark, that shall either present so majestic a front as may effectually daunt our aspiring enemy; or, should he attempt to assail us, may heap deserved ruin upon his head."

THE BIGGEST FLAT-TOP

EARLY next month the U.S.S. *Forrestal* (59,650 tons) is due to be launched from the Newport News, Virginia, shipbuilding yard. With a flight deck 1,036ft long and 252ft wide, she will be the world's largest warship. The vessel has an angled flight deck, and four steam catapults from which it will be possible to launch 32 aircraft in four minutes. (The angled deck and the steam catapult were both invented by officers of the Royal Navy.) The flight deck covers three acres, and a sponson extending round the island provides additional aircraft parking space. Both the main aircraft lifts are outboard, amidships.

It was originally intended that the whole island should retract to leave a completely clear flush deck, but this scheme was modified in favour of the hinged masts and funnels which are necessary to allow the *Forrestal* to pass under Brooklyn Bridge to the New York Navy Yard.

All gun turrets are automatically controlled and special drenching rooms are provided for use after atomic attack. The 200,000 h.p. engines are designed to produce a speed of 30 kt with the aid of two four-bladed screws inboard and two five-bladed screws outboard; there are three rudders. The engine room is designed to function automatically for many hours should the staff be put out of action. *Forrestal* will have a complement of 3,500 men.

AUSTRALIAN MISSION VISITS BRITAIN

AS recorded in our British Commonwealth special number published on August 27th, a great deal of thought is being given to the re-equipment of the Royal Australian Air Force. Within the limits of a comparatively small budget, and bearing in mind the country's desire to be self-sufficient with the aid of the three principal manufacturers in Australia, a choice must be made of the next fighter, medium bomber, jet trainer and transport. The Government and Commonwealth factories are at present producing Canberras and Avon-Sabres, and the de Havilland Company of Australia are building Vampire Trainers, but to ensure continuity the successors of both the Sabres and Canberras must be selected almost immediately and manufacturing licences obtained.

With this task in mind an important Australian Overseas Aircraft Mission recently arrived in London for a six-weeks' visit and study of British aircraft. The Mission is led by Air Vice-Marshal A. M. Murdoch, C.B.E., and the members are as follows:—G/C. B. A. Eaton, D.S.O., D.F.C., and G/C. E. Hey, O.B.E., Director of Technical Services (from the Department of Air); Mr. J. Hanford Stevens, A.F.R.Ae.S., Assistant Secretary, Aircraft Production; Mr. N. W. Hodgson, A.M.I.P.E., manager, Government Aircraft Factory; and Mr. I. B. Fleming, M.Sc., A.F.R.Ae.S., chief designer, Government Aircraft Factory (from the Department of Defence Production); Mr. D. G. Humphries, Chief Designer of Commonwealth Aircraft Corporation Pty., Ltd.

After completing its investigations in the United Kingdom the Mission will go to the United States before returning to Australia.

CU-NIM RESEARCH REPORT

A SEVENTEEN-PAGE pamphlet* issued by the Meteorological Office deals with a programme of cumulus and cumulo-nimbus cloud-penetration flights carried out between April 18th and June 18th, 1950, by R.A.F. Transport Command Development Unit with a Lancaster based at Singapore. The flights were made over Malaya and Sumatra.

It was found that the transition from cumulus to cumulo-nimbus occurred when the cloud-tops were between 30,000ft and 33,000ft. (i.e., where the temperatures were about −30 to −35 deg. C); that cumulo-nimbus on occasions reached the tropo-pause at approximately 55,000ft; and that, contrary to experience in middle latitudes, radar echoes were received from cumulus clouds the tops of which were well below the 0 deg C level. It was apparent that practically all turbulence areas could be avoided if the radar response areas were circumnavigated by about one mile.

Observations of hail, snow, sleet, lightning and turbulence carried out during penetrations in cumulo-nimbus clouds were the first of their kind to be made in the tropics, and the pamphlet deals to some extent with these also. Some of the results of the flights have been compared with conclusions drawn from the comparable American investigation with P-61 Black Widows flying in several parts of the U.S.A.

* *"Cumulus and Cumulo-Nimbus Cloud over Malaya," by R. Frost, B.A. (H.M. Stationery Office, Ref. M.O.535j, price 1s.)*

SWEDISH TEST-FLYING

Some Notes on the Development of Modern Jet Fighters

THIS article is by Mr. O. Ekstrand, a project flight test engineer of the great Swedish Saab organization, in whose house publication "Saab Sonics" it first appeared. Eminently readable, it gives an insight into some of the problems met in testing jet fighters.

THE testing of a new type of aircraft must be planned right from the earliest project stage. This means that the staff who are to carry out the testing must be thoroughly familiar with the aircraft and its background. On the basis of this knowledge, it is decided what testing is necessary, and a test programme is worked out.

It is not sufficient, however, simply to decide in good time what is to be tested: one must also consider how and when the testing is to be done, and what instruments will be needed. Many measurements require cables and indicators in parts of the aircraft which cannot be reached after it has been completed. Other measurements may require instruments or apparatus which must be specially manufactured or bought from abroad, and which may have a long delivery time.

The number of prototype aircraft is limited for economic reasons. This means that to the greatest possible extent one endeavours to relieve the prototype of all tests which can be done equally well in test-rigs and testing shops on the ground. Only final checking is thus done on the actual aircraft to verify the ground test results.

The installations for the ground testing of the various systems or parts of the aircraft are often very large and complicated, and require a long time to design and construct. It is therefore essential to start in good time, as the results of the most important ground tests should be available before the first prototype is ready to fly.

Even during the initial design work and calculation, the designer comes up against problems which cannot be solved theoretically, and tests must be resorted to. Another reason for testing may be that the part in question is so important to the aircraft that its strength must be checked for safety's sake. Such parts are, for example, the wing/fuselage joint, control surfaces, tailplane, cockpit hood, pilot's seat, control surface hinge brackets, etc.

Probably the most important and certainly the most impressive of the strength tests is the "ultimate test." To this end a whole aircraft is built, complete as far as the load-carrying structure is concerned. It does not have any engine, fuel system, etc.; it is just an empty shell.

This airframe is loaded in different ways to correspond to various flight loading cases, such as the high-speed dive case, the pull-out to high load factor case, and gust cases on fin and rudder.

To test the undercarriage, a drop-test is made with the whole test airframe. This is arranged so that the entire aircraft, complete with undercarriage, is dropped from the calculated height, and at the moment of contact the stresses are measured at critical points on wings, fuselage and undercarriage. To obtain spin-up loads on landing, the wheels are set to rotate in the reverse direction before the aircraft is released.

After the test airframe has been thoroughly tested without at any time exceeding the design load, loading is carried out to failure—ultimate load—in some characteristic flight case, usually the pull-out case. The aircraft is subject to successively increased load until it fails. An idea of the margin of safety is thereby obtained, and the weakest point of the design established.

A modern aircraft contains a large number of very complicated systems. To cure the principal shortcomings and make the systems work as reliably as possible before the prototype flies, the more vital of these are generally given functional tests in special test rigs.

Thus, a complete full-scale fuel system is built in the laboratory. The test rig is so made that it can be rotated about different axes. In each position such things as the fuel supply from the reserve to the main tanks, fuel flow to the engine, refilling times for diving compartments, etc., are investigated. Perspex windows are inserted in the pipelines and tanks, and through these any aeration or eddies in the fuel may be studied. Parts of the system which are difficult to perfect are made entirely of Perspex for ease of observation.

On modern aircraft with servo controls the hydraulic system is often very complicated and it is therefore usual to build a rig to test this. This rig also is built to full scale so that full-length circuits are obtained throughout. The hydraulic test rig gives the answers to such questions as: Is the capacity of the pumps sufficient? Are the systems sensitive to resonance? Are the stick forces at the pilot's controls suitable? Is the cooling of the hydraulic fluid adequate?, etc.

The third wheel of an aircraft, whether it be a tail or nose wheel, often shows a tendency to shimmy at certain rolling speeds. In order to test various types of shimmy dampers a test carriage is built with correct landing gear geometry and centre of gravity. This carriage is then towed along on the runway whilst attempts are made to cause nosewheel shimmy by different means. The carriage, which on account of its aesthetically unattractive appearance goes by the name of "the helicopter", also lends itself excellently to the testing of nosewheel steering.

The most important installation from the military angle is the armament. To ensure that the armament functions correctly, a weapon-firing mock-up is built. This consists of the forward part of the aircraft complete with armament. It is made so that it can be mounted in different positions to reproduce the conditions of firing during diving or climbing. Comprehensive firing tests are carried out with the mock-up to guarantee positive ammunition feed in all attitudes.

Meanwhile, whilst the tests outlined above are being made, the first prototype has been built and one day the workshops hand over to the testing department a complete aircraft ready for their attentions.

All points which appeared in earlier ground tests have been given due consideration in the preparation of the aircraft. Nevertheless everything is tested once again before the aircraft is approved for flight.

The last days before the first flight are hectic, with a horde of test personnel from different specialist departments all wanting to check their own particular part, creeping all over the aircraft, both inside and out. In spite of the will to co-operate, and the fact that team-spirit is good, everyone cannot work at the same time. The night hours are therefore resorted to by many in order to be alone with the aircraft and their problem.

Some days later the aircraft is taken out and the engine started. Then for the first time all the ancillary systems receive their power from the proper source. When work has reached this stage everyone working on the machine is usually exhausted by night work, but now the day of the first flight is at hand and minor adjustments outstanding on the engine and instrumentation are dealt with quickly.

The day comes when the pilot sits in his aircraft and taxies out on to the runway in order to get the feel of the aircraft up to take-off speed. At the same time, a good check can be made on the wheel brakes and the ground manœuvrability of the aircraft.

After this final phase, a new aircraft type is ready for its maiden flight.

Before we pass on to the actual flight tests, a few words must be said about the most important aid in testing an aircraft—the instrumentation. On a modern aircraft this is most compre-

Three prototypes of the Saab A32 Lansen, Sweden's excellent transonic, two-seat, Avon-powered machine which is now in production for all-weather attack, night fighter and reconnaissance wings. A dual-control variant is to be built.

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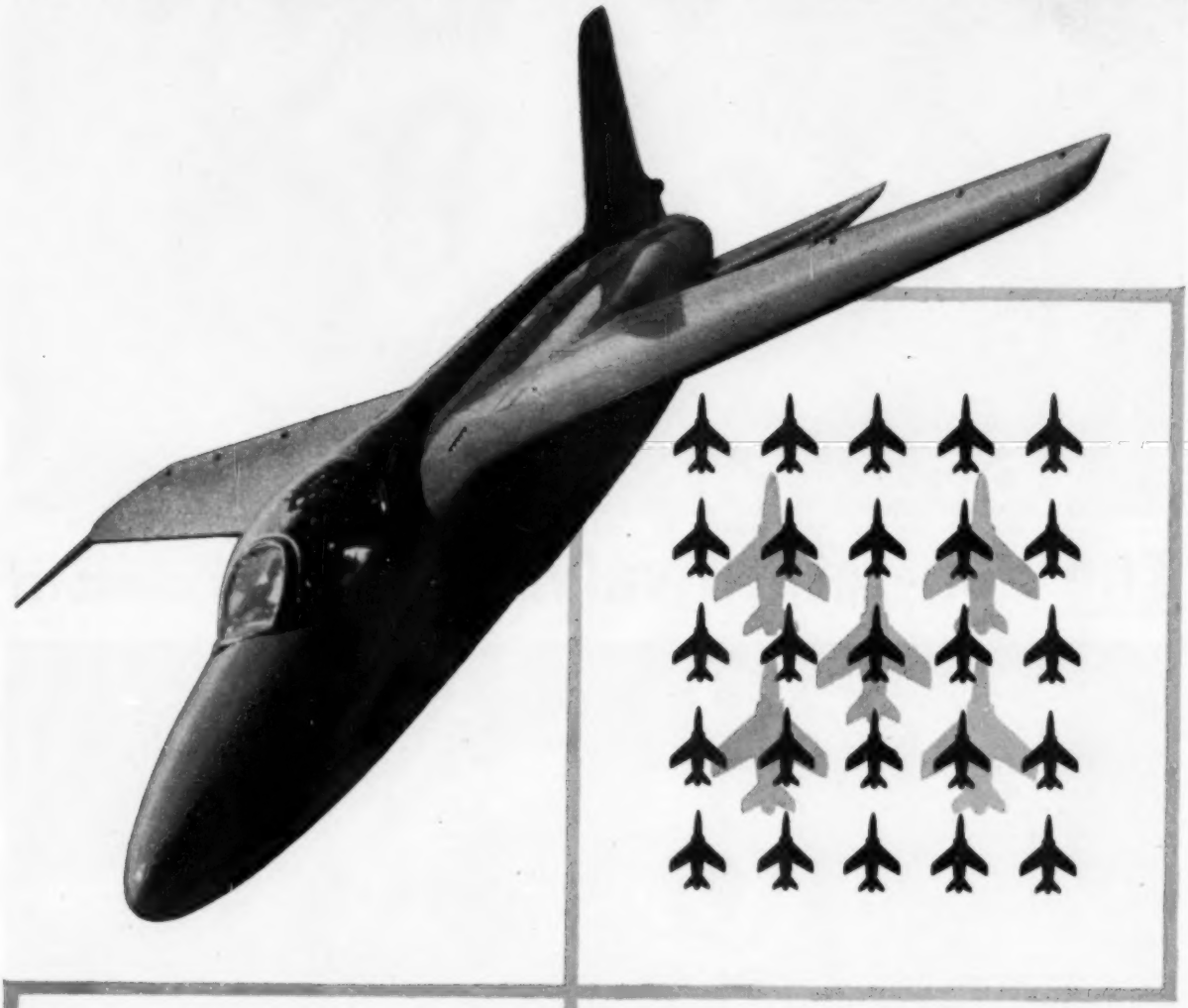

❶ *Production*

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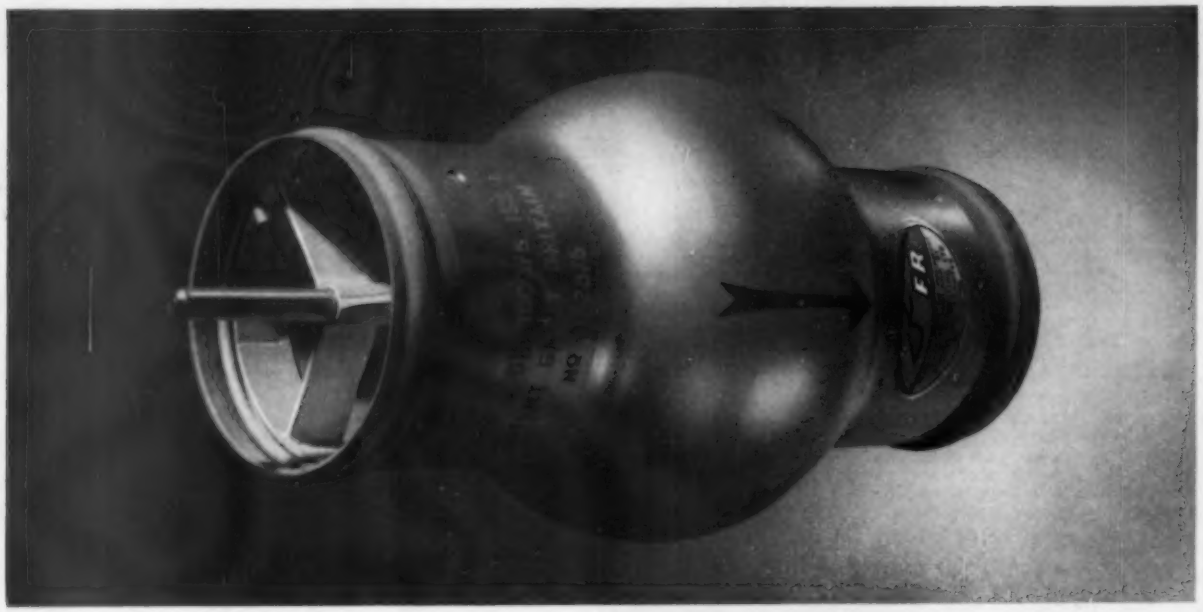

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hensive, the total weight of the instruments, apparatus and cables being between 1,300 and 1,600 lb (600-700 kg) on an aircraft of the type of the Saab-32 Lansen.

To find room for this quantity of equipment, it must be planned in the aircraft design stage. Sometimes extensive alterations have to be made in the design to satisfy the demands of the instrumentation technicians.

The accommodation in the prototype normally intended for armament, navigation aids, sights, etc., is usually used to house the instrumentation equipment. In multi-seat aircraft the empty positions can be used for temporary measuring equipment, as normally only a one-man crew is required. If in spite of this, space is not sufficient for the instrumentation, such drastic measures must be taken as the removal of a fuel tank for the sake of measuring apparatus and leads.

Apart from the ordinary instrument panel in the pilot's cockpit, a large number of instruments are collected on a separate instrument panel elsewhere in the aircraft. Readings from these are recorded photographically, the pilot operating the camera by a button on his panel. The camera panel has room for 20-25 instruments, which can thus be read simultaneously as frequently as eight times a second if desired.

A number of other cameras in the aircraft can also be operated simultaneously with this one. For example, a camera can be placed in the fuselage to photograph wool tufts on the wings, or in the wing tip to photograph the side of the fuselage. It has even occurred that a camera has been mounted in front of the pilot to record his facial expressions at high rates of acceleration.

The real work-horse in the measuring equipment is the oscillograph. This has usually 12 or 24 galvanometer coils which record on a continuously moving film. Every such coil can, of course, measure one variable. Through a selector switch, different measuring points can be connected successively to the same oscillograph coil whilst the film is in motion. For pressure and temperature measurements it is usual to have three selector switches, each of which can feed in about 50 measuring points on the same coil whilst it turns through one revolution. A revolution of the selector takes about 4 seconds, and the working cycle is commenced every time the pilot presses the operating button.

Concisely, the above shows that 4 seconds after the pilot presses the button about 200 readings are recorded, after which the equipment is ready to begin a new exposure cycle immediately.

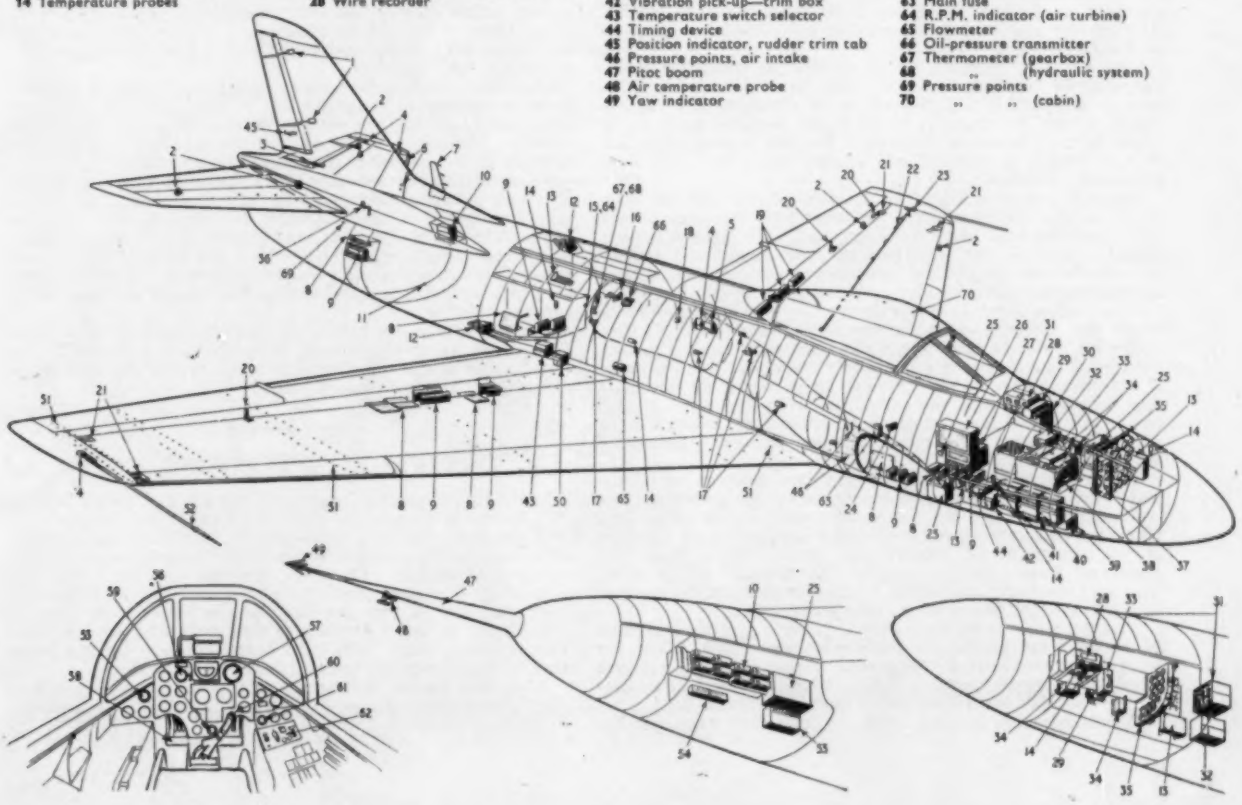
During a test flight of about 1 hour, the pilot takes, on the average, about 100 exposures. This means that after landing and developing the film about 20,000 readings from the flight are available. This figure has no practical significance, but is mentioned only to show the enormous possibilities of the instrumentation. The advantage of extensive instrumentation is that comprehensive measurements can be taken in widely differing parts of the machine without the necessity of keeping it on the ground for lengthy re-connection of instruments between flights. One of the most difficult jobs afterwards is to sort out from the sea of readings those which are relevant to a certain test or flight condition. These, which roughly speaking are about 2 per cent of the total number of readings, are evaluated and made further use of.

The wire recorder is a very convenient item of equipment for the pilot. This makes a recording of everything the pilot says during a flight. When anything worth noting happens, or when one of the instruments in the cabin has to be read or noted down, the pilot need only talk to himself. The sound goes to the recorder *via* the microphone in his oxygen mask. After the flight, the recorder is played back and the contents taken down in shorthand and typed out.

When, after years of work, a new prototype is at last ready for its first flight, expectations are great, and the excitement grips everyone. Representatives from the Air Force are sent to

Some idea of the extensive test equipment required in a modern military prototype is provided by this diagram of the Saab Lansen.

1 Rudder position indicator
2 Vibration pick-up
3 Elevator position indicator
4 Accelerometer, horizontal
5 ,, vertical
6 Temperature points, tailplane
7 Pitot comb
8 Pressure pipeline connectors
9 Pressure pick-ups
10 Bridge unit for strain gauges
11 Pressure points behind air brake
12 Electrical connection plugs
13 ,, ,, ,,
14 Temperature probes
15 Valve position indicator
16 Indicator, air-brake
17 Pressure pick-ups
18 Flap position indicator
19 Connector box, strain gauges
20 Aileron position indicator
21 Photo index point
22 Torsion measurement tube
23 Pick-up for measurement tube
24 Aileron gearbox position indicator
25 Accumulator
26 Pick-up connection panel
27 Control instrumentation box
28 Wire recorder
29 Gyro converter
30 Oscillograph (12-channel)
31 Bridge unit for pressure readings
32 Converter
33 Camera
34 Angular velocity indicator
35 Automatic observer panel
36 Tailplane position indicator
37 Pipe connector panel
38 Oscillograph (24-channel)
39 Main switch selector
40 Bridge unit potentiometers
41 Pressure switches selector
42 Vibration pick-up—trim box
43 Temperature switch selector
44 Timing device
45 Position indicator, rudder trim tab
46 Pressure points, air intake
47 Pitot boom
48 Air temperature probe
49 Yaw indicator
50 Camera (wing surface)
51 Wing pressure points
52 Pitot tube
53 Strain-gauge distributor box
54 ,, ,, box
55 Indicator dial aileron gear
56 ,, ,, trim tab
57 ,, ,, oil pressure gearbox
58 Pedal force transmitter
59 Flowmeter counter
60 Stick-force transmitter
61 Thermometer (oil)
62 Manoeuvre box
63 Main fuse
64 R.P.M. indicator (air turbine)
65 Flowmeter
66 Oil-pressure transmitter
67 Thermometer (gearbox)
68 ,, (hydraulic system)
69 Pressure points
70 ,, ,, (cabin)



SWEDISH TEST-FLYING . . .

witness the event. The thorough and comprehensive preparations which have been made guarantee that no major unforeseen incidents will occur, but nevertheless it is a thrilling moment, a thrill which, I guess, is the same as that felt by an explorer when he stands at the frontiers of an unexplored land. The unknown draws and fascinates, but one approaches it with the greatest care and respect.

The first flight does not yield much purely technical result, but actually only verifies that everything is as it should be, and that testing can begin.

During the subsequent flights, height and speed are carefully increased and the stalling properties, engine operation, etc., are checked, making intensive use of measuring equipment. In this phase of testing one meets many problems which demand solution before one can proceed further, and throughout its duration, which may be anything from one or two to six months, the aircraft itself decides what is to be done.

The most varied problems can crop up. On the Saab-32, for example, strange acoustical phenomena occurred in the air intake and motor at certain combinations of engine revolutions and airspeed. The aircraft has one engine with a double intake. To analyse the problem more closely, comprehensive pressure measurements were taken in and around the air intakes. It was then discovered that at low revs and high airspeed (diving) when the supply of air was greater than necessary, the airflow was such that it came in through one intake and out through the other. It was in connection with this that the sound phenomena occurred. With the aid of the pressure readings taken, the necessary alterations could gradually be made to the intake until the trouble finally completely disappeared.

Through these alterations to the air intake another trouble, which had never previously been cleared up, was also cured, namely vibrations in the rear fuselage of the aircraft at high Mach numbers. These had been a nuisance, and several attempts to localize the source of the vibrations had been in vain.

Comprehensive measurements are taken of pressure and temperature at different points in the aircraft during this period of the testing to check the working conditions for particular pieces of apparatus and system. The object of most detailed study is the engine. To work satisfactorily, this must have the correct pressures and temperatures internally and externally. It must have the correct amount of cooling air, properly adjusted pressure in vent pipes and drain tubes, and much more besides.

The trials quickly proceed, as outlined above, and the problems that crop up are solved one by one.

Pilot, engineers and mechanics learn to know their aircraft and its peculiarities better. As they do so, the test flight frequency rises, because inspection time between flights can be made shorter and because the weather need not be so good as for the early flights.

After the first troubles, which usually go under the worn out name of "teething troubles," have been cleared up, there comes a period of tests during which, by systematic and routine flights, effects are made to establish the aircraft's qualities in respect of stability and performance. For this, a programme has been arranged in advance and special, often very sensitive, instruments obtained.

The test pattern during this phase is usually that the pilot climbs to the desired altitude and then puts the aircraft into some predetermined flight condition, e.g., level flight at certain engine r.p.m., or turn with constant load factor. At regular intervals he photographs the instruments, and records verbally all observations and subjective opinions on the wire recorder.

After such a flight there is a large collection of measurements which the different specialists eagerly appropriate for further evaluation. Comparisons are made with corresponding results from wind tunnel tests or from purely theoretical investigations. If the comparisons do not turn out satisfactorily the upshot is new tests—either with the prototype or in the wind tunnel, employing other methods or more refined instruments. No one rests content until every disparity can be satisfactorily explained.

The checking of the basic stressing data demands very comprehensive pressure and stress measurements during flight. Pressure recording points are positioned mainly in the wings and also often on access doors and detachable panels on the fuselage, on the canopy, or the undercarriage doors. Strain gauges are positioned mainly on the load-carrying structure of the wing. The total number of measuring points used to check the strength of a new aircraft type is somewhere about 1,000.

In some cases the strength of an important part of the aircraft is checked by measuring the deformation under load. Thus, the wing tips have been photographed during flight by cameras fitted in the fuselage, with the object of measuring the deformation of the wing when subjected to high load factors.

A prototype can be very capricious, and even when one has progressed to the stage when the routine testing is going according to plan, and it is thought that most of the problems have been solved, the most unexpected things sometimes happen. Naturally, these incidents always happen inconveniently, and completely upset the test programme which has been worked out, and on such an occasion the machine must be treated with the same patience and indulgence that one extends to one's child.

One pilot observed, for example, that with a certain combination of control movement, speed, and load factor, vibrations occurred in a servo-operated flying control. No one could decide from the pilot's description if it was a harmless vibration or control flutter. The new problem was discussed with specialists, the aircraft was fitted up with instruments, and careful tests were planned. After a lot of extra work, the characteristic and cause of the phenomenon were established, and yet another trouble was resolved.

On another occasion it so happened that on a flight which was to all intents and purposes normal, the fire warning light suddenly showed. The pilot, of course, operated the fire extinguishers and landed immediately. On inspection of the aircraft, it was found that the warning was caused by a short circuit between two terminals in an electrical junction box, through which current had reached the warning lamps.

Once whilst diving from a high altitude test, the pilot chanced to hear a dull report from inside the aircraft. Believing it to be an explosion in the engine nacelle he cut out the engine, shut off the fuel supply, and glided in. In the inspection which followed, no signs of an explosion could be found. Part after part was dismantled and inspected without anyone being able to find an explanation for the bang. Soon the pilot began to be disbelieved, and he and his story treated more and more sceptically. Then, by chance, someone laid a hand on a large unstiffened panel in a tank so that the curvature which was present in the panel went over with a loud report to the other direction. There was the explanation. The panel had given whilst flying, due to the change of pressure between the tank's inner and outer sides occasioned by the rapid change of altitude.

When delivery of the first production aircraft starts, testing of the prototype must have reached such a stage that any troubles which may cause modifications in design have been overcome and the modifications incorporated in the production aircraft. In addition, the stability and performance characteristics of the machine must be so well established that handling notes can be written.

Having got so far, one would think that the testing would be at an end. That is not the case, however. Experience shows that the prototypes and the testing staff are fully occupied for a further long period.

When the production aircraft begin flying, new problems often crop up. This may be on account of the fact that the production aircraft is not exactly like the prototype in detail because of being designed for ease of production. Other reasons may be that the quality of material or apparatus from contractors has altered during production.

Generally a new version of the aircraft is developed, and this demands renewed or supplementary testing. The most common development is that the type is fitted with a more powerful engine. Sometimes it is adapted for another purpose, for example from a fighter to a reconnaissance machine.

From what has been said above, it should be clear that testing of a new aircraft, contrary to the beliefs of some, takes up a very long period of time. During this time, testing is carried out with the help of several prototype aircraft, the best instruments and measuring methods which can be obtained, with a group of the cleverest pilots and technicians it is possible to get, and with all possible speed having due regard to flying safety and the weather.

These efforts on the part of the aircraft manufacturer to make the testing as thorough and comprehensive as possible are intended to act as assurance that the result, the production aircraft, will be a satisfactory product.

CONTRACTS AND COMMUNISTS

OFF-SHORE contracts placed in Europe by the Mutual Defence Assistance Programme all carry a clause which specifies that such contracts shall be fulfilled only by "non-Communist firms," or at least by organizations in which the preponderant influence is non-Communist. The U.S. Embassy in Rome has now announced that some contracts placed with Italian firms have been cancelled on this ground; and that other work must be farmed out, as far as possible, to employees who are not Communist sympathizers. The latter course has been adopted in the case of the Sabre-repair contract held by Fiat, of Turin.

Altogether the position seems very difficult, particularly since the Communist-dominated C.G.I.L. is overwhelmingly powerful in Italian trade-union circles.

Air Power at Sea

H.M.S. ILLUSTRIOUS

The first ship to bear the name *Illustrious* was a 74-gun third-rate. Many of the famous 74's were originally three-deck ships but had the top deck removed and hence were known by the French term "Razees". They served the Navy in the eighteenth century. The fleet carrier *Illustrious* of 23,000 tons, her modern successor, is the fourth ship of that name. Armed with her striking force of naval aircraft, she upheld the highest traditions of the Royal Navy in battle after battle between 1939 and 1945. Operating from the oceans of the world, shipborne Fairey aircraft in *Illustrious* brought many combat successes to her long list of "Battle Honours".

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DH PROPELLERS

DE HAVILLAND PROPELLERS

This aircraft, appropriately lettered VP-KPR and flown here by "Punch" Bearcroft, was the first Tri-Pacer delivered to the Kenya Police Reserve Air Wing.

AIRCRAFT VERSUS MAU MAU

"Flight" photographs

THIS appraisal of the part played by aviation in the Kenya Security Forces' campaign against Mau Mau terrorists is by a member of "Flight's" editorial staff, Robert J. Blackburn, who has recently been touring East Africa and was able to see and photograph operations at first hand. Throughout the Kenya emergency, which has now lasted for over two years, aircraft have been used to locate and attack terrorists, and to support the ground forces. The large Mau Mau gangs have been broken up, but the battle is not yet over, and air activity is on a larger scale than ever before.

ONE need go no farther than Nairobi, the capital of Kenya, to see signs of the seriousness of the emergency. The firearms, for instance, which are carried not only by troops and police but also by civilians of both sexes—and this despite the fact that loss of a gun can bring a £250 fine or three months' imprisonment. Terrorist activity within the city boundaries is now confined largely to occasional night-time sorties by small groups in search of arms, food or clothing.

But though 20,000 Mau Mau have been killed or captured in the past two years, it is thought that 7,000 are still at liberty. Liquidation of these tenacious "hard-core" terrorists, most of whom have formed small, nomadic bands within 100 miles of Nairobi, appears the only way of preventing the Mau Mau disease from lingering—and, perhaps, spreading—indefinitely.

The only reason for the decrease in the number of outrages committed by Mau Mau is the fact that the security forces are now very much on the offensive. Today there are three Government actions to every one initiated by the terrorists, compared with a ratio of one to two during the first six months of the emergency.

Most of the Mau Mau have withdrawn into two areas of deep forest—the Aberdare Mountains, to the north-west of Nairobi, and Mount Kenya, to the north-east. Strikes, sweeps and supply drops are flown daily over these areas by pilots of the Kenya Police Reserve Air Wing and the R.A.F. The work of land and air forces is co-ordinated by "J.O.C."—the Joint Operations Centre in Nairobi.

The Air Wing has been in action since the very first days of the emergency. It was, in fact, formed as far back as 1948, its inception coinciding with the end of subsidized private flying in East Africa. The moving spirit behind the idea was W/C. A. N. Francombe, D.S.O., M.B.E., a former chief pilot of East African Airways and now the full-time provincial commandant of the Air Wing, with headquarters at Nairobi West Airport.

When the emergency began the Wing had only one aircraft, an Auster. Today it operates ten Piper Tri-Pacers, a Cessna 180 and a Chipmunk, and four more aircraft—two Cessnas and two Tri-Pacers—may shortly be added. There are 17 full-time pilots and eight part-time pilots, each of whom puts in one day's flying per week.

One recent Sunday morning, when I visited W/C. Francombe at Nairobi West, I learned something of the unusual tasks which these sturdy light aeroplanes are called upon to perform. A request to see the Wing in action resulted in a flight, the next day, to Mweiga, the main operational base. I travelled to Mweiga, which is about 65 miles north of Nairobi, in the communications aircraft, the luxuriously appointed Cessna 180, flown by one of the Wing's senior pilots, Pakenham Walsh. The route took us over the Reserves, where a quarter of a million Kikuyu, Embu and Meru live in protected villages. This is pleasant country to view from the air—almost artificial-looking in the symmetry of its undulations and the patchwork of cultivation spread across its red soil. As Mweiga approached, Walsh turned the Cessna towards the foothills of the Aberdares. Nothing moved on the dusty roads, and if any terrorists lurked in the dense forest they did so without risk of observation from

"Field Marshal" Kaleba, with escort, about to board the Rapide for Nairobi. The circumstances of his capture are described overleaf.

AIRCRAFT VERSUS MAU MAU . . .

above. Occasionally, on hilltops, we saw fenced-in clusters of tents and tin-roofed huts—Army or Home Guard encampments.

We landed on the Mweiga strip just before the Chipmunk, which makes a daily mail round of the Air Wing bases. Mweiga, which has a grass runway prepared by the Kenya Regiment, has been the main base since July 1953. It has a thoroughly operational air, with its barbed-wire compound enclosing tents and a thatched mess for the eight resident pilots, headed by Commandant "Punch" Bearcroft. "Punch" proved to be a tanned wiry figure in khaki with a manner that was at once brisk and friendly. The loss of a hand (in a motor cycle accident) has had no apparent effect on his flying. He and the other Mweiga pilots usually fly three or four 40-minute sorties daily, and they contribute 500-600 hr monthly to the Air Wing's total of over 1,000 operational hours per month.

Typical Kenya landscape photographed from the Air Wing's Cessna 180: above, the Kikuyu reserves, and (below) an isolated Home Guard outpost in the Aberdare Forest.

Harvard "Gremlin's Castle," flown by F/O. Mike Holmes, tucks in close to the C.O.'s aircraft on the way to the target. Note the 19 lb fragmentation bombs. At top right the Air Wing's Cessna 180 is seen taking off from Mweiga, and below it is Priory Field, a new air-strip typical of those used by the Police aircraft in Kenya.

The Tri-Pacers carry three radios, including an Ekco 88 (walkie-talkie) enabling their pilots to relay messages to ground patrols. Sometimes it is also used to locate Army patrols, which may well be unaware of their exact position after travelling for several days in thick, featureless forest. In such cases contact can be entirely aural, troops and pilot being hidden from each other's sight by foliage; the aircraft flies to a given approximate position and is brought over the patrol by radio instructions from the troops, who use the engine noise as a guide. When supply dropping is required, patrols indicate the dropping-zone by means of a fire, or by coloured smoke signals. Supplies are dropped without parachutes, usually in 50 lb bundles.

On other occasions the Pacers are required to bomb suspected hides or to mark targets for the Army's guns. Their armament consists of four 19 lb fragmentation bombs, which are carried on an external rack beneath the rear part of the cabin. In addition, phosphorous grenades can be thrown from the cockpit, serving the dual purpose of marker and anti-personnel bomb. Opportunities to attack visually are rare, but kills have been scored against groups of terrorists caught off their guard by patrolling Pacers. No one knows how often the enemy shoots back, though the police aircraft sometimes return with wings holed by bullets. However, the general standard of marksmanship among the Mau Mau is known to be poor, and it is estimated that the ratio of bandits to precision weapons is about seven to one.

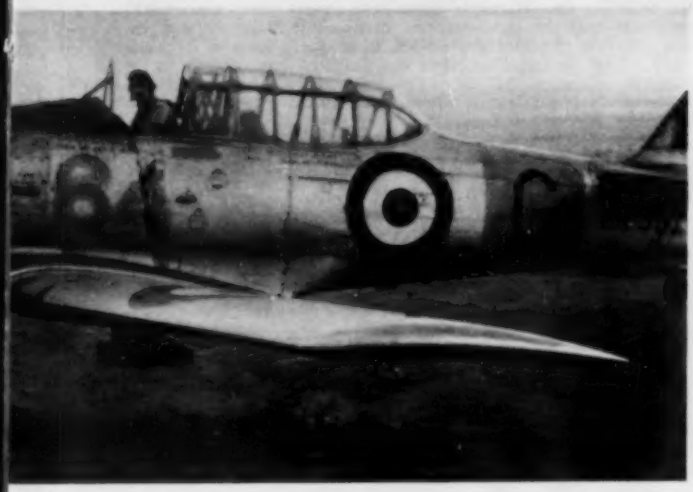
Another rôle of the Air Wing is casualty evacuation, made possible by removing the rear seats of the Tri-Pacer. The little Piper's load-carrying ability is one of several reasons for its selection. Another is high-altitude performance. Mweiga is 6,200ft above sea level and the highest of the outlying strips is no less than 8,000ft, the equivalent density altitude being in the region of 11,000ft. The Tri-Pacer takes these conditions in its stride. It has unstuck at Mweiga in only 120 yd with two men aboard plus fuel, and it has frequently been landed on roads. Its normal endurance is six hours, which can be increased to seven by using low cruising r.p.m. To these features can be added relative cheapness (a fly-away cost in the region of £3,000) and ready availability.

Virtually no servicing is performed at Mweiga or Nakuru, the Air Wing's other operational base. After 25 hours' flying the

aircraft return to Nairobi West for a maintenance check in the hangars of Campling Bros. and Vanderwal, Ltd. Their pilots have great faith in both the reliability of the aircraft and the quality of servicing. "Touch wood," said Bearcroft, "we have not had a single mechanical failure in two years of operation."

But though the hazard of unreliability can be reduced to a minimum, the Air Wing and R.A.F. pilots alike also face the risks of flying in all weathers over inhospitable country peopled, in the prohibited areas, by unfriendly natives. A 300 hr air search for one of the Pacers, which vanished on June 26th, was unsuccessful, even though the aircraft was known to be within a five-mile square patch of bamboo forest. The density of the forest is such that the wreck was not located until three months later, from information supplied by a captured terrorist. Altogether, five Harvards, three Tri-Pacers and a Lincoln have been lost during the campaign.

Close support of the ground forces entails frequent landings at some 35 strips—20 in the Aberdares and 15 around the foot



of Mount Kenya—hewn out of bush land on the fringe of the forest, the majority being sited near company bases.

On arrival at Mweiga my curiosity was aroused by the sight of a dozen or so heavily armed African soldiers standing by a truck parked at the head of the strip. I learned that they were guarding "Field Marshal" Kaleba, a Mau Mau leader captured the previous night while sleeping in a cave with three accomplices. The troops and police who arrested them also found in the cave property from the farm of Mr. A. G. A. Leakey, which had been raided by terrorists some ten days earlier. Mrs. Leakey was murdered on the spot; her husband was abducted and, it is now believed, buried alive on Mount Kenya.

Soon afterwards W/C. Francombe arrived to pick up Kaleba, flying a Rapide chartered from Noon and Pearce. Manacled hand and foot, and closely guarded, the prisoner was taken out to board the aircraft for Nairobi, interrogation and trial.

Leaving Mweiga in the Cessna, we flew close by Tree Tops Hotel, where H.M. the Queen stayed on the eve of her accession to the throne. The house itself has since been burned down by terrorists, but the charred skeleton of the tree which supported it is still standing. As we passed over this historic spot Tri-Pacer 'KPR, flown by Bearcroft, joined us in brief farewell before turning back to Mweiga and bombing-up for his next sortie.

From Nairobi West I made my way to the city's international airport at Eastleigh, where R.A.F. operations are centred. There, in the operations room, I met S/L. K. R. Bowhill, C.O. of 214 Squadron, which has had six Lincolns in Kenya on detachment from their home base at Upwood since June 10th. In its first four-and-a-half months of operation, I was told, the squadron had dropped nearly 1,500 tons of bombs, all the while increasing its intensity of effort. The number of bombing strikes in a month had increased from 40 to 180. The Lincolns were carrying a standard offensive load of 14 500 lb bombs and 1,000 rounds of 0.5in ammunition. Earlier, while flying over the Aberdares, I had noticed the brown patches of uprooted trees and scorched foliage left in the green forest by the 500-pounders, which have a 450 yd radius of serious blast effect.

The Lincolns are sometimes called upon to bomb a pin-point target at the request of forward patrols. More often, however, their targets are selected by Joint Operations Centre after interpretation of photographic survey by Meteors—two Eastleigh-based P.R.10s on detachment from the Middle East. Whenever skies are sufficiently clear these Meteors, with full internal and external fuel tanks, make long sorties over the prohibited areas at around 30,000ft. Such is the quality of interpretation at J.O.C. that vertical photography, even from this altitude, is often the best source of information on terrorist movements.

Whenever possible, photographs showing the actual bomb-bursts are taken by Lincoln crews for subsequent comparison with the P.R. target pictures. This procedure has stimulated keen rivalry between crews and, judging from a selection of comparative views shown me by S/L. Bowhill, has helped in the attainment of a very high standard of bombing accuracy. Visual attacks are made from the "safe bombing height," which usually means about 3,000 or 4,000ft above ground level. Radar is used in cloudy weather or at night, when attacks are made from heights of up to 10,000ft. The mean bombing error achieved by radar is in the region of 200 yd. At the time of my visit about 80 per cent of the Lincolns' operations were being flown by day.

Also based at Eastleigh is a "sky-shouting" Auster, which broadcasts exhortations to the Mau Mau by means of tape-recordings in the Kikuyu language. I heard it suggested that the first appearance of the sky-shouter was the cause of short-lived jubilation among the Mau Mau who, unable to catch the theme of its message but identifying the language correctly, assumed that Dedan Kimathi, their leader, had formed his own air force. This may be an exaggeration, but it is known that several terrorists were caught off guard by the Security Forces

A Lincoln of No. 214 Squadron taxies away from dispersal at Eastleigh for a bombing attack on Mau Mau terrorists. Squadrons earlier engaged in the campaign were Nos. 49 and 61.

Pilots of the Kenya Police Reserve Air Wing, photographed at Mweiga: (Left to right) Ian Munro, Bill Jones, "Punch" Bearcroft, Pakenham Walsh and Robin Lindsay.

AIRCRAFT VERSUS MAU MAU . . .

while listening to an aerial broadcast.

During my short stay at Eastleigh tests were being conducted with a Pembroke equipped with sky-shouting apparatus and four outsize loud-speakers mounted in the fuselage entrance door. I assumed that some ironing-out of acoustics had yet to be performed, because it was possible to grasp only a few words of its transmissions. A still later addition to the Eastleigh air force, then being uncrated, was a Bristol 171 Sycamore, the first helicopter to be used in the campaign. Earlier this year a flight of Vampires operated from Eastleigh but was withdrawn to the Middle East after a short period.

Among the most hard-worked of the military units in action against Mau Mau is No. 1340 Flight, commanded by S/L. C. G. St. David-Jeffries, D.F.C., and equipped with 12 Harvards; of these four are normally kept in reserve and at any one time there are usually two under inspection.

Bearing in mind, therefore, that it was achieved with a first-line fleet of six aircraft flown by eight pilots, the following record for September is all the more impressive: 504 sorties flown, 3,974 bombs dropped, 187,240 rounds of ammunition fired and 532 operational hours flown. An idea of the current intensity of operation is given by the fact that since the Harvards were first used to support the Security Forces in April last year, the total number of sorties flown is about 3,900; about one-sixth of the total operational hours flown by Harvards over the eighteen-month period was logged in September.

No. 1340 Flight pilots' individual monthly hours have, on occasions, exceeded three figures—an out-of-the-ordinary achievement for any Service pilot, and particularly for one flying single-engined aircraft on relatively short sorties.

The armament of the Harvard is comparatively light, consisting of eight 19 lb fragmentation bombs (though these can be lethal at 200 yd) and 450 rounds of 0.303 ammunition fired from a single gun in the starboard wing. Nevertheless, there is much evidence of the devastation wrought among gangs of Mau Mau by these ageing and battered, but much-respected, trainers. The manœuvrability of the Harvard is its greatest asset in these operational conditions, and reliability is ensured by 1340 Flight's keen and hard-working servicing crews. The pilots would welcome more engine power, since the Harvards are cruising almost continuously at or above their rated altitude and frequently there is no power-margin available.

Most attacks begin with a shallow dive from 9,000 to 11,000ft above sea level and each successive pass at the target must be made from a lower height, but S/L. Jeffries emphasized that "If the gang is there, our weapons are sufficient." Just how sufficient is indicated by interrogation of "surrenderees," who are now coming in at the rate of 20 or so per week. Here is a typical extract from a prisoner's statement: "Gatheru S/O Wairegu—surrendered September 5th, 1954. In July 1953 he was at a meeting called by Dedan Kimathi on the Aberdare Moorlands. Approximately 1,000 Mau Mau were there when the area was attacked by nine Harvards. The meeting broke up and he states that casualties were high. In January 1954 he was bombed on the Chania. Of 145 in his gang he states that 105 were killed. He went back to the area a week later and saw some bodies. On September 3rd, 1954, he was with a gang of seven which was bombed. No casualties were inflicted but as a result of this attack he and two others surrendered."

One of the most significant tributes to the efficiency of the air offensive is the fact that most captured terrorists speak of being bombed several times, the attacks often being concentrated within a period of a few weeks or even days. There are grounds for believing that Harvards alone have in fact killed some 1,000 terrorists over the past eighteen months. It is known that on one occasion two Harvards killed 20 out of a gang of 24 Mau Mau. Last Boxing Day, after the death of Earl Wavell in an ambush, Harvards hit the main and secondary hides of the terrorists responsible and killed 32 of them. Their sorties are normally concentrated within two periods of the day: from 6 a.m. in the morning up to lunch time, and during twilight. Actual sightings of Mau Mau are rare; I was told that, altogether, Harvard pilots have spotted the enemy on only about twelve occasions.

Learning that Harvard pilots normally fly alone I expressed a wish to see a typical sortie from the rear cockpit. It seemed as though I would be unlucky, for the station was enjoying a three-day stand-down—its first in eighteen months. S/L. Jeffries, however, promised a consolation ride over the forest early the following morning. The promise had barely been made when word came through that the Seventh K.A.R.s believed they had located remnants of the Kaleba gang, whose leader I had seen taken into custody only that morning. Stand-down or no stand-down, the services of two Harvards were required. Within half an hour we were airborne in a calm evening sky, with sunset imminent on our port side. Tucked-in close to starboard—see photograph—was another Harvard, flown by F/O. Mike Holmes (late of Biggin Hill). S/L. Jeffries is a stickler for close formation flying and I had no difficulty in reading the name *Gremlins' Castle* written small on its weatherbeaten cowling.

Our target was a bend in the Sagana River, about 25 minutes Harvard-time (at 110 kt indicated) from Eastleigh. As the minutes passed S/L. Jeffries indicated points of interest. Ahead of us loomed the snow-capped bulk of Mount Kenya. To our left was the Leakeys' house, and on the right the Royal Lodge, a wedding gift to the Queen from the people of Kenya.

"And here"—the nose of the Harvard dipped, but S/L. Jeffries' voice still sounded quite casual—"is our target." We skimmed the trees, following the line of the river bed, and pulled up into a steep climbing turn. A line of grey-brown puffs of smoke studded the meandering line of the river.

We made three more passes along the target, and this time the flame from the Browning gun flickered bright orange against the dark green foliage.

A few hundred feet away the accompanying Harvard was administering the same treatment to the Rukurua River. We flew back low ("to boost the morale of the settlers") in echelon, navigation lights glowing in the gathering dusk. The sortie was over, successfully completed. Ahead lay the brightness of Nairobi; behind, the darkness of the forest.

The Air Wing's Cessna 180 receives attention in the hangars of Compling Bros. and Vanderwal at Nairobi West.

★ The Sapphire is manufactured under licence by the Wright Aeronautical Division of the Curtiss-Wright Corporation in the U.S.A., where it is known as the Wright J.65.

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F9F-9 TIGER *fighter*

★ *The*
MARTIN B57 *(Canberra bomber)*

The Gloster
JAVELIN *all-weather fighter*

The English Electric
P.1. *fighter*

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FURY *fighter*

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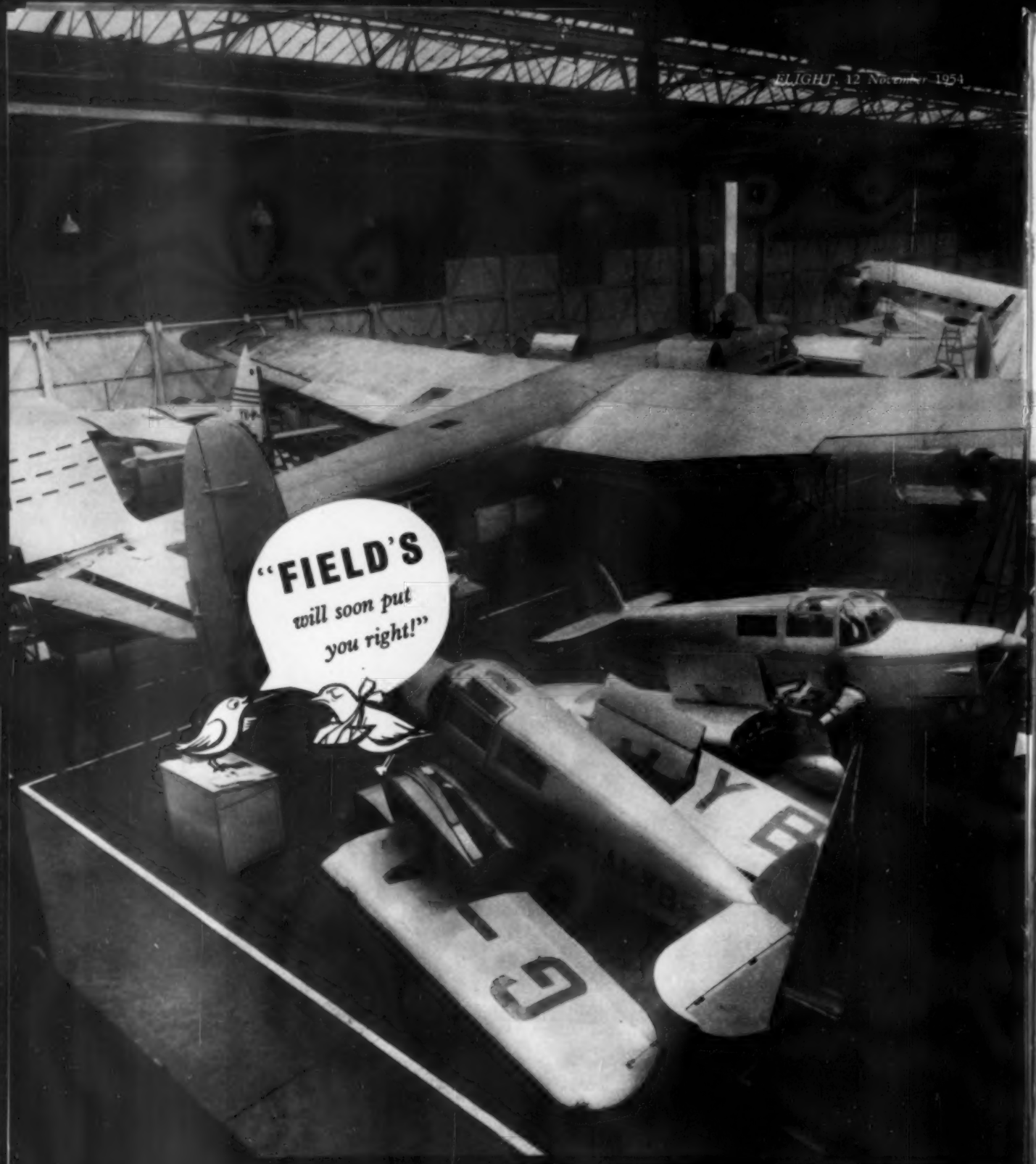

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BOUNDARY-LAYER CONTROL

Dr. Lachmann's Important R.Ae.S. Lecture Summarized

YESTERDAY, November 11th, the director of research to Handley Page, Ltd., Dr. G. V. Lachmann, D.Ing., F.R.Ae.S., was due to present a "main" lecture to the Royal Aeronautical Society. The subject was boundary-layer control, in which field he has himself been working for many years. Though he was precluded, on security grounds, from describing any of the experiments which are at present taking place under his auspices, his paper was a masterly exposition.

Dr. Lachmann began by saying that the year 1954 was memorable as marking the fiftieth anniversary of Prandtl's classical demonstration of the effect of boundary-layer suction on the flow pattern around a cylinder and also because most convincing demonstrations of practical applications of the idea had taken place. In fact, the present time might later be recognized as one in which an important evolution of design philosophy occurred.

A school of thought had been growing up leading away from the classical conception of the aeroplane in which the power-plant served solely for the production of thrust to pull lift-producing wings through the air. The new concept, which had been greatly stimulated by the introduction of the gas turbine, led away from the motorized glider (characteristic of most aircraft since the Wright brothers) to a new vehicle in which the power-plant and wings were closely integrated with the engine, contributing to the combined requirements of propulsion and lift.

The new philosophy had many branches and was not confined to fixed-wing aircraft. An extreme manifestation was the production of direct lift without the intermediary of circulation (the "flying bedstead"). Another branch consisted of by-passing some power to control the boundary layer and wing circulation.

Modern methods of boundary-layer control for the purpose of preventing separation were based on the principles of either infusing kinetic energy into the flow or removing the boundary layer by sucking it through the wing-skin. Although research workers had long been attracted by the idea of developing methods of boundary-layer control, both for increasing lift and laminarizing, the majority of aircraft designers were inclined to consider the subject as impracticable and academic. The advent of the gas turbine had now provided a useful reservoir of compressed air for both blowing and suction, and the practical outlook had now changed decisively; furthermore, the introduction of swept wings, thin aerofoils and increasing wing loadings emphasized the need for higher lift coefficients.

The lecturer first turned his attention to the application of boundary-layer control to prevent separation of flow at, for example, the sharp nose of a high-speed aerofoil, in order to increase the lift to higher angles of attack than would be possible with the plain section.

The first practical form of automatic boundary-layer control was the leading-edge slot. When the slot was open the boundary layer flowed off the trailing edge of the slat but was separated from that of the wing by the secondary airflow through the slot itself. The positions of the slat leading and trailing edges were such that the pressure gradients were favourable to prevent any separation; the slotted flap improved the ordinary trailing-edge flap in the same manner by delaying separation at the hinge and allowing a higher circulation to develop over the main wing.

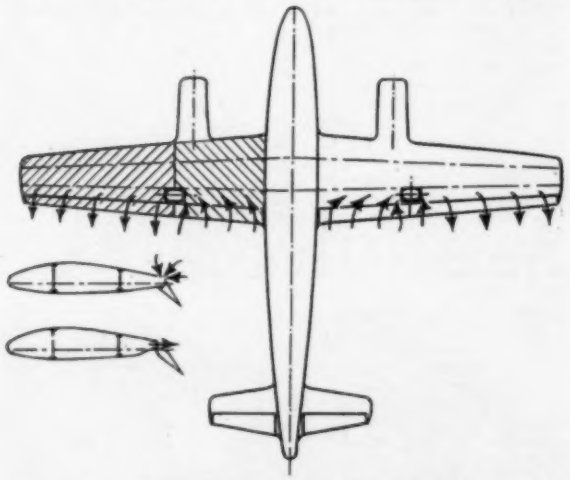

Fig. 1. The Arado system of sucking and blowing a single flow of air, the sections showing the types of flap employed on the inner wing (sucking) and outer wing (blowing).

The stream of air coming from the slot had the same effect as a jet pump in infusing kinetic energy into the boundary layer. This had led Professor Baumann to consider blowing a stream of air at suitable points of the contour to accelerate the boundary layer. By so doing, the velocity of the secondary stream could be chosen at will, as could its position. Separation could thus be prevented either by established methods of slots or nose flaps, or alternatively by removing excessive boundary layer by suction through porous material or through a slot near the leading edge, or again, by infusing kinetic energy into the boundary layer and improving the process of the entrainment by blowing air out tangentially to the wing profile.

The classical method of circulation control, in contrast to extending the usable range of the lift curve, was the trailing-edge flap. When a normal flap, slotted or unslotted, was deflected (other parameters remaining the same) the increase in lift due to large flap angles was substantially less than theory predicted. The principal reason was the strong adverse pressure gradient on the upper surface of the aerofoil leading to separation of the boundary layer at the flap. This could be prevented either by sucking away near the flap hinge or by blowing through a slit ahead of the flap. The Coanda effect caused this secondary flow to adhere to the curvature of the flap nose, and thus it was possible to bend the flow over the flap and achieve the full theoretical lift increase.

A method of increasing circulation without using a flap originated in Germany during the war. A relatively large slot was situated near the trailing edge of an unflapped aerofoil through which the boundary layer and part of the potential flow was to be removed.

At this point Dr. John Williams of the N.P.L. was mentioned by the lecturer as having recently published a very valuable analysis of aerodynamic data on blowing over trailing-edge flaps to increase lift.

One of Dr. Lachmann's diagrams showed that if the "blowing momentum coefficient" were increased beyond the value corresponding to theoretical maximum lift for a normal flap when the flow was completely attached to the flap, it was possible to obtain yet a further increase in lift, interpreted by American workers as a "super circulation." This could be regarded as arising from an effective extension of the flap chord and from the vertical component of the jet reaction.

Dr. Williams had considered that there was need for further high-lift testing with blowing over trailing-edge flaps, particularly on straight and swept wings and at high Reynolds numbers. Dr. Lachmann also thought there was room for the study of other methods for preventing separation of flow from the flap.

Dr. Lachmann outlined the history of developments in this sphere and noted that in 1938 Miles built an aircraft with a perforated wing-skin for boundary-layer control, preceded only by a Fieseler Storch which was flown in about 1936. R.A.E. experiments of the early war years were mentioned by the lecturer, as were the tunnel tests by W. H. Paine (Westland Aircraft) concerned with blowing out over a flap on a swept wing. He also discussed German work, notably a combined sucking and blowing system developed for Arado and Dornier aircraft during the war. As shown in Fig. 1, the air over the inner half of the span was sucked away and then expelled through a slot over the outer wings. This arrangement made possible economy of ducting and pump power. On the Me 109 the boundary-layer control was to be effected solely by blowing over the flaps. The need for increasing the lift coefficient resulted from the use of symmetrical sections of the laminar-flow type of only 9 per cent t/c ratio. Air was to be supplied by two blowers located inside the wings and driven by extension shafts from the main engine. Eventually it was found possible to prevent the main airstream from separating even with flap deflections of about 60 degrees.

Dr. Lachmann remarked that although the results of this work became available in 1945 it found relatively little response in Great Britain; this, he concluded, may have been due to poor translations and bad representation of the results.

The Arado system had, however, been demonstrated on an

BOUNDARY-LAYER CONTROL . . .

American Cessna 170 aircraft. Designated Cessna 309, the aircraft was modified under a Navy contract and was demonstrated at Anacostia, showing complete controllability at a speed 11 m.p.h. below the normal stalling speed. The take-off distance was reduced by about 40 per cent.

The lecturer showed a remarkable tunnel photograph (Fig. 2) obtained at the U.S. Navy Bureau of Aeronautics, illustrating the high-lift system using blowing without suction. Mr. John Attinello, said Dr. Lachmann, had been principally responsible, and his method had been demonstrated on a Grumman Panther jet fighter. The take-off speed was reduced by 20 kt and the under-wing load could be increased by 3,000 lb; pilots were very satisfied with the modified Panther and felt great confidence in flying the aircraft right down to the lowest possible speeds. The sweeping success of this demonstration had a far-reaching effect on the American industry.

Although the Attinello flap was not the most economical application from the mass-flow requirement, it certainly could be applied readily to most modern aircraft.

The lecturer also made reference to work by the French O.N.E.R.A. establishment. Air was bled from a turbojet to energize a series of flattened jet-pump nozzles exhausting over the flap; double flaps were arranged to permit suction at the first opening of the flap from the suction side of the pump with subsequent exhaustion of the air over the rear flap. Suction was also applied at the drooped leading edge on the thin swept wing employed. This arrangement provided an increase in lift coefficient of 1.36.

Dr. Lachmann then considered general take-off problems and noted that supersonic aircraft with very low aspect-ratios could not obtain high lift-coefficients. Since such aircraft needed at least a reasonable lift-coefficient and had thrust/weight ratios approaching unity it became logical to utilize thrust for lifting purposes. For transport aircraft, it was possible to use an engine of minimum size determined by cruising thrust without throttling, or a larger engine could be chosen and cruised in a throttled condition. The latter engine would have a better specific fuel consumption and the aircraft would thus need a lower take-off lift coefficient; there would therefore be an optimum size of engine and a corresponding value of lift coefficient for a given requirement, at which the combined weight of power plant and fuel became the minimum.

The lecturer went on to discuss landing problems and noted that again it was imperative to depart from conventional techniques on aircraft of low aspect-ratio by improving the utilization of thrust for landing. The lecturer summarized this section by pointing out that all swept-wing aircraft would benefit from the higher lifting capacity due to circulation control and that flap construction could be made simpler and lighter. The choice of maximum lift coefficient depended on thrust and span loading and should be considered simultaneously with the power plant. Technically, blowing was much simpler than sucking, although mass-flow requirements were greater. Dr. Lachmann felt that the emphasis had shifted from tunnel research to engineering and installation experiment and considered that the United States' achievements were due to determined efforts to tackle the "plumbing" and to undertake full-scale flight research. In both respects a good deal of leeway had to be made up in this country.

The lecturer went on to give an extensive history of laminarization through boundary-layer control, together with the associated theory.

He then discussed the two basic methods which had been tried out, namely, distributed suction and suction through discrete sinks. The former method employed a porous skin such as nylon or rolled gauze, while the latter usually employed narrow slots where a favourable sink effect was utilized. The argument in favour of slots was that diffuser-shaped slots permitted some pressure recovery, whereas suction through a porous material destroyed all dynamic pressure. On the other hand, slots had to be made to fine tolerances, and in model tests it was observed that they required frequent honing to keep the edges sharp. The lecturer himself introduced the method of sucking through discrete strips either of porous material or of rows of perforations; this formed an effective compromise (Figs. 3 and 5).

Fig. 2. A tunnel photograph by the U.S. Navy Bureau of Aeronautics showing a wing with the Attinello blow-out flap at a high angle of attack with what is termed supercirculation.

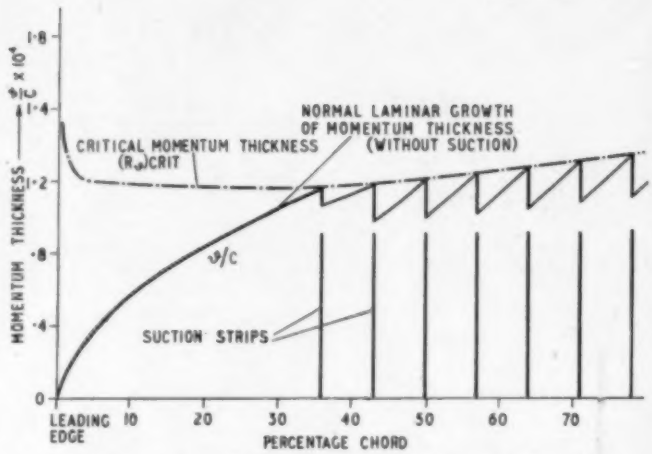

Fig. 3. The first suction-strip is positioned at the point at which the curve of boundary-layer growth approaches the critical value, and other strips maintain the momentum-thickness below the limit.

In the extensive treatment of theoretical considerations which followed, Dr. Lachmann showed that over-sucking led to transition due to roughness effect, and insufficient suction led to instability. By closing up the strip spacing, stability could be ensured with reduced local suction and less reduction of boundary-layer thickness. At the same time relatively greater surface roughness became tolerable. The lecturer examined at length the question of roughness, and concluded the height of an isolated roughess-element should, to avoid catastrophic transition, be less than half the displacement thickness of the boundary layer. Requirements relating to surface finish became more stringent as unit Reynolds number $\left(\frac{U}{\nu}\right)$ increased. This applied particularly to the forward part of the aerofoil, where the boundary layer was very thin; here a very smooth skin was essential, and it was considered advisable to rely on the natural laminar state for a certain distance, since it was generally easier to obtain a smooth impervious surface than a porous one. The natural laminar front should overlap the sucked portion by a reasonable margin, and it should be ensured that there were no isolated kinks or adverse pressure gradients near the leading edge within the desired range of lift coefficients.

Roughness was understood to include manufacturing deformations and fly- and dust-accretion. These were probably the most serious causes of destabilization of a laminar boundary layer, but there were other causes, such as waviness of the skin, and the out-flow which could occur when the pressure drop through the porous surface was smaller than the outer pressure gradient in a spanwise or chordwise direction. There was also a possibility of instability due to secondary flow normal to the outer stream lines. W. E. Gray of the R.A.E. discovered in 1952 by visual observation that sweep angle had a profound destabilizing effect on the laminar boundary layer. Fig. 4 was reproduced by Dr. Lachmann, who had been permitted to publish the results of the subsequent investigation for the first time.

It was found that the instability started in the form of chordwise striations spaced at distinct intervals. The instability was later associated with a secondary flow in the boundary layer caused by the curvature, in planes tangential to the wing's surface, of the stream lines just outside the layer. The velocity profile in this secondary flow (measured normal to the wing surface in a plane perpendicular to the stream lines in the outer flow) attained a point of inflexion, indicating that dynamic instability of the secondary flow could be expected to develop above a certain Reynolds number, ultimately leading to the formation of vortices with axes roughly parallel to the outer flow direction.

Tunnel testing showed that, for a given sweep angle, three distinct changes in the boundary layer could be detected as the air speed was increased. At low speeds, transition remained far back from the leading edge at the position appropriate to zero sweep (approximately 65 per cent chord). At a fairly well defined speed, striations in the china clay [this was the method used to show separation] became visible, starting near the leading edge without any immediate effect on transition. With a small increase in speed, the striation pattern intensified and transition began to move forward. As the speed increased further, the transition progressed to the leading edge. The forward movement was gradual with small angles of sweep and more sudden at large angles. The conclusion was that it was preferable either to keep sweep-back below 20 degrees or to apply pronounced sweep of the order of 60 degrees combined with very low thickness/chord ratios.

Dr. Lachmann went on to consider various types of laminar wing for different purposes, one of which had a wing section at the root with the point of maximum suction very far aft with the suction position moving gradually towards the leading edge over the outer and thinner portions of the wings where less sweep of the isobars was necessary for the same critical Mach numbers.

The paper then considered some practical design considerations. Some of the essential requirements were already shown to be: local surface roughness less than half local boundary-layer displacement thickness; waviness under 0.003in within a 3in curvature gauge for unit Reynolds number up to 2.5×10^7; and, pressure drop through the suction surface should be greater than pressure variations in spanwise or chordwise direction on the surface. In addition to these desiderata was the requirement that the suction surface should not appreciably increase the weight of the wing structure, neither should it require excessive maintenance.

It was understood that the latest ideas could not be disclosed; nevertheless some basic principles were described in recent British patent specifications, one by Mr. M. R. Head and the other by the author of the present paper. The first specification concerned distributed suction and comprised an inner sheet with an outer skin of porous material separated by a lattice of web members sub-dividing the interspace into a number of cells, each of which communicated through an opening in the inner skin to a suction chamber. Simple flap-type non-return valves were to be fitted to the openings in the inner skin to avoid out-flow with suction inoperative. The structure was also such that the porous outer skin was always lightly loaded relative to the inner skin and cell-forming lattice.

A similar method was specified in one of the author's patents, in which the structural element comprised a corrugated sheet inner skin and an integral-milled outer skin over which was stretched the final porous surface. Further applications of the principle of integrating a non-stressed porous member to a skin panel incorporating the suction ducts as load-carrying members were the subject of another patent from which the drawing on page 714 is taken. These patents refer to the method of suction through discrete strips of porous material spaced at chordwise intervals with intermediate portions of impervious skin. The strips were inserted in the outer skin by means of a sliding fit with the shear flow in the outer skin by-passing the porous strip to leave the latter substantially unstressed.

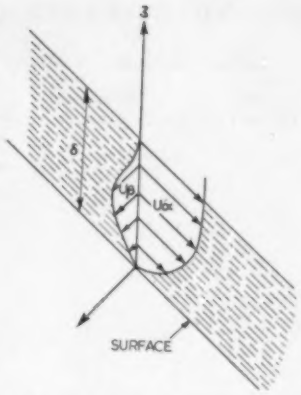

Fig. 4. Shown for the first time, this diagram illustrates the effect of sweep-back in destabilizing the boundary layer. The secondary flow is resolved along, and perpendicular to, the stream-lines just outside the boundary layer. The component normal to the wing surface contains a point of inflexion (see text).

Both patents dated from 1950. Broadly speaking, the principles disclosed had been found feasible, but a good deal of effort had since been devoted to translating them into a suitable form of "hardware."

The degree of surface smoothness required implied very accurate manufacture, and it was considered that one had to look forward to new forms of construction. It might be possible to use prefabricated sheets of plastic material (incorporating a suitable type of porosity) bonded to the upper surface of a metal panel in sandwich construction utilizing stress-carrying members as ducts.

There was no fundamental reason why the fuselage and other parts of the aircraft should not be treated in this way. Such things as engine and undercarriage doors should, ideally, be avoided, as should be spanwise and chordwise joints and gaps, and this might be achieved were some form of circulation control to replace present-day ailerons and flaps.

Turning to considerations of the compressor and ducting, Dr. Lachmann considered that a subsonic axial compressor with a pressure ratio of 2.5 or 3 to 1 might be used, with three stages each aspiring air simultaneously at different pressure levels. This compressor could be driven by any of a number of schemes, the preferable arrangement being a direct power take-off from a turbine fed by gas or compressed-air generators.

Methods of propulsion for laminarized aircraft were then discussed by the lecturer, who showed that the power plant had to be integrated closely with the aircraft if full benefits were to be realized. It was not sufficient merely to remove part of the boundary layer, but it was also necessary to re-energize the sucked air to free-stream velocity. In other words, laminarization through boundary-layer suction comprised implicitly a form of re-energizing the boundary layer. The step from there to boundary-layer propulsion was short and obvious. Some of the conclusions of this reasoning (by Dr. Pfenninger) could be summarized as follows:—

(a) Turboprops driving suction blowers which ejected the sucked air at velocity somewhat in excess of flight speed had the highest overall efficiency.

(b) The efficiency of a turbine driving a suction blower (without propeller) approached that of a turboprop as the ratio pump drag/total drag increased.

(c) A turbine driving a suction blower had a higher efficiency than a ducted fan of the same weight ratio of $\frac{\text{turbine air}}{\text{air}}$, since part of the thrust was produced by decelerated boundary layer and not from undisturbed air.

(d) The efficiency of a straight jet using suction air was inferior to the foregoing; and

(e) The overall efficiency of a gas turbine *cum* suction blower could be improved by an additional ducted fan in lieu of a propeller.

It was obviously uneconomical to carry an over-size power-plant for main propulsion, and a better solution seemed to be to have an efficient cruising engine, supported by a suction plant made as light and powerful as possible brought into use only during the take-off and climb. The reduction in the size of engines corresponding to the greatly reduced cruising thrust required by the laminarized aircraft might enable the designer to choose unorthodox engine arrangements, such as gas-generator plants or compressors energizing dispersed turbines driving ducted fans and suction blowers situated in the most suitable positions.

Dr. Lachmann noted that the reduced thrust required, coupled with the reduced efflux velocity of any form of boundary-layer

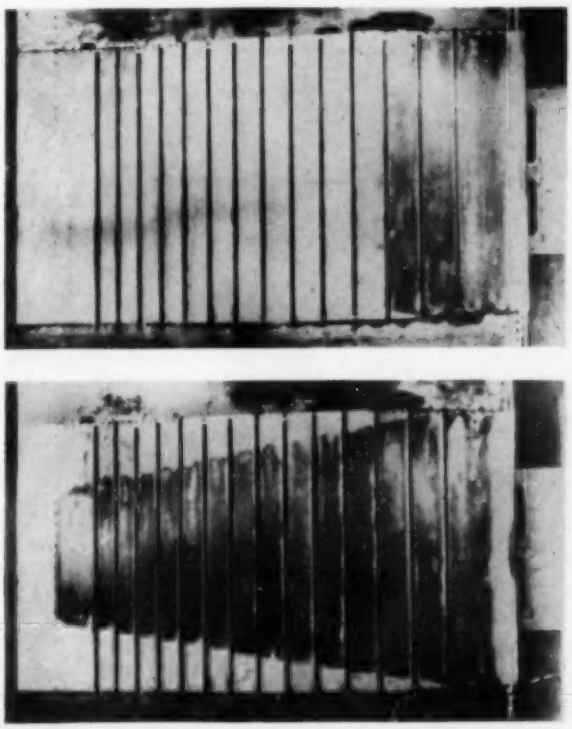

Fig. 5. A Handley Page test wing of several years ago; above, without suction, transition at 0.28 chord (leading edge on right) with C_d surface 0.00322; below, with suction, transition at 0.93 chord, with effective total C^d of 0.00115 (wake 0.00078, pump 0.00037).

BOUNDARY-LAYER CONTROL . . .

propulsion, would certainly make possible a great reduction in noise.

The lecturer's last principal section considered a typical four-engined transport in laminarized and turbulent (i.e. conventional) forms. In the ideal case of an aircraft with completely laminar flow over the whole of its wetted surface, only one quarter of the thrust of the turbulent aircraft would be required, range being about 150 per cent greater and optimum cruising altitude about 20 per cent less. For 50 per cent laminarization the corresponding figures were: thrust reduction, 50 per cent; range increase, 45 per cent; and reduction of optimum cruising altitude, 14 per cent.

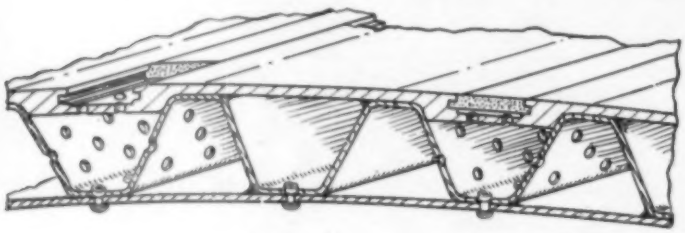

Fig. 6. Redrawn from a Handley Page patent specification applied for in 1950, this is one of the methods proposed for manufacturing the wing upper surface.

In his conclusions, the lecturer considered that laminarization was becoming less important for military applications, particularly where supersonic speed was necessary, except where extreme range was a requirement or where cruising for part of the flight could be done at a high subsonic Mach number. Reconnaissance, anti-submarine and transport aircraft should, however, benefit from the improvements in range and fuel economy and from the possibility of designing such aircraft at reduced size and all-up weight for a given range and load. It should also be possible to obtain very high lift coefficients by circulation control, with corresponding benefits in landing and take-off characteristics.

Dr. Lachmann ventured to predict that the bulk of passenger- and freight-carrying aircraft would stay subsonic for a long time to come. In this regime, laminarization through boundary-layer control and re-energization of the boundary layer remained the only fundamental aerodynamic possibilities for improving the economy of flight.

THE AERONAUTICAL BOOKSHELF

"The Dangerous Skies," by A. Cdre. A. E. Clouston, D.S.O., D.F.C., A.F.C. and bar. Cassell and Co., Ltd., 37 St. Andrew's Hill, London, E.C.4. Illustrated. Price 13s 6d.

ALL too frequently one reads that flying is not what it was in the pioneer days—that excitement and enterprise have given way to slide rules and red tape. What nonsense it is!

One has only to read this book to be reassured that there is always adventure in the air, if one cares to look for it. And, in any case, the "pioneering days" of flight are by no means over.

They had just started in 1908, when Arthur Clouston was born in New Zealand. Eighteen years later, the Wright brothers, Curtiss, Farman and Roe had been succeeded by a second generation of pioneers, who proved the practicability of the aeroplane for long over-water flights. One of the greatest was Sir Charles Kingsford Smith, and it was his arrival in Christchurch, soon after flying the Pacific in the *Southern Cross*, which first made Clouston want to fly.

Shortly afterwards, Lord Wakefield presented New Zealand aero clubs with six Moths, and Clouston was able to learn to fly on these, going solo after 4½ hours. But there was little prospect of continuing to fly with the R.N.Z.A.F., so he came to England with the idea of getting a short service commission in the R.A.F. Like many of our finest pilots, he very nearly "pipped" his medical; but managed to scrape through and eventually began his own pioneering by becoming one of the first pilots to take part in tied-together formation aerobatics, flying a Fury of No. 25 Squadron.

After that, he was appointed one of the first two civilian test pilots at Farnborough, where he got off to a good start by proclaiming the Envoy "the biggest basket that has ever been in the air," after it had passed all its tests in the hands of more experienced test pilots. He was little more impressed with his first flight in an Autogiro; yet in due course he became not only the chief Autogiro pilot at R.A.E., but private test pilot to Raoul Hafner, who had just built his promising little A.R.III Gyroplane.

There are some excellent and often horrific stories of Clouston's experiences at Farnborough, especially those describing his research into ice formation, which involved flying into thunder clouds in a Courier and, later, a much-modified Heyford and a Northrop monoplane. But for sheer courage, the account of balloon barrage tests, during which he flew a Fairey P.4/34 into cables that sometimes cut deeply into the main spar, takes some beating. There are first-class photographs of these various tests; but, unfortunately, none showing the complete, specially modified aircraft.

Then came an equally dangerous period trying to test Flying Fleas, and the start of his well-known series of record attempts in a Miles Hawk Six and one of the 1934 Comet racers. There has never been a better account of the hard work and dangers that such flights entail, or of the lessons they taught. For example, after the 1937 Circuit of Europe race, Clouston wrote a report on his crossing of the Alps which was distributed to R.A.F. pilots. The last paragraph records:—

"To have to sit in the Comet with no parachute, whilst both engines failed to tick over, and to have to spiral three times between the mountains in ice, hail and rain clouds during the course of an hour, with nothing but the altimeter to indicate whether ground is above or below, is the most horrible feeling I have ever experienced."

Dangerous skies indeed; but there was plenty more excitement to come. He became one of the first men ever to be offered (and to refuse) a million pounds for a single job—in this case a mere matter of murdering Hitler with a well-placed bomb from the Comet! He was the first person to use an anti-spin parachute when a Queen Wasp got out of control during a test flight. Interesting war-time experiments in which he was involved included firing photoflash flares from a gun mounted in a Havoc, to illuminate enemy bombers for our night fighters; dropping "wire curtains"; and remote control from the air of speedboats—the idea being to fill them with explosive and guide them into the sides of the *Scharnhorst* and *Gneisenau* at Brest.

Nor is that all, for Clouston got back into uniform in 1942 and served with distinction on operations and in command of Coastal Squadrons. Post-war, he was posted to Germany and New Zealand; then became Commandant of the Empire Test Pilots' School, before returning to Coastal Command last year as S.A.S.O. of No. 19 Group. Better than most people, he knows how much pioneering remains to be done. Little wonder that such a man should long to be eighteen again, to take up the challenge.

"The Young Traveller in Space," by Arthur C. Clarke. Phoenix House, Ltd., 38 William IV Street, London, W.C.2. Illustrated. Price 7s. 6d.

APART from a few more expensive or more technical works, this is perhaps the best-yet book on space travel. Inevitably it has much in common with the others—including the same old picture of two "weightless" mice!—but the name of the author guarantees its accuracy and commonsense; it is up-to-date; and incredibly good value for 7s 6d.

The text and the 36 large illustrations cover the full story from Cyrano de Bergerac to the V.2 rocket, earth satellite vehicles and flights to the Moon and planets. Inevitably, the solutions to immense problems of space-flight are made to appear too easy. But any boy (or father!) who wants a sound basic knowledge of interplanetary plans and progress, at modest cost, could do no better than buy *The Young Traveller in Space*.

"The Green Hills of Earth," by Robert A. Heinlein. Sidgwick and Jackson, 44 Museum Street, London, W.C.1. Price 9s 6d.

EVEN those who are not regular readers of science fiction could hardly fail to find this book of short stories entertaining. To start with, Mr. Heinlein takes no chances on accuracy of detail. The end-papers consist of charts recording the outstanding technical and sociological developments of the years 1960 to 2600, and pinpoint the precise period in which each story is set.

The stories themselves are first-class. Mr. Heinlein makes use of current knowledge and speculation in describing the difficulties that a child born on the Moon would experience after landing on Earth. He also introduces a few new and unpleasant possibilities, such as Moon-quakes and exploitation of the planets by slave labour. In fact, after reading of the foul, flooded jungles of Venus, the frozen night of Titan and the harsh bright soil of Luna, "the cool green hills of earth" seem more attractive than ever, even without weather control!

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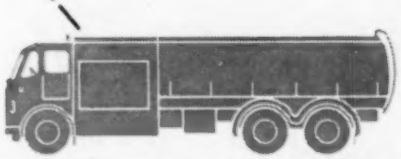

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THE COMET INQUIRY: THIRD WEEK

Further Evidence on the Accidents, and Expert Views on Future Possibilities

FOLLOWING our two previous reports on the Comet Accident Inquiry being held at Church House, Westminster, this account deals with the evidence put forward between Monday, November 1st, and Friday, November 5th. Among the new witnesses called at the beginning of the week was Lord Brabazon of Tara, chairman of the Air Registration Board.

Monday, November 1st: Eighth Day.—Most of this day's evidence was given by Sir Arnold Hall (Director of the Royal Aircraft Establishment and a member of the Air Safety Board), who was recalled to give further details on points which had arisen since his first testimony. Examined by Sir Lionel Heald for the Crown, and cross-examined by counsel for the various interested parties, he described the basis for the decision to resume services after the Elba accident, and his own opinion on the future of the Comet.

Mr. E. L. Ripley, head of the R.A.E. Accidents Investigation Section, was first cross-examined by Mr. J. Whitford (for Aero Research, Ltd.) concerning the behaviour of the Redux joints in Comet YP. The examination of the wreckage, Mr. Ripley said, had shown that the only failures of Redux had been secondary failures, caused after the initial disruption of the cabin in the air, or on impact with the sea. Riveted joints had failed just as much as Redux joints during this process of secondary failure.

Mr. Ripley agreed that neither type of joint was designed to stand up to the sort of loads and stresses which occurred during these secondary failures. The primary failure of the pressure cabin had not taken place at the rear portion of the fuselage, where some secondary failures of Redux had appeared, and there was no evidence that temperature or pressure had affected the adhesive in any way.

The witness concluded by giving details of dates when particular parts had been received at Farnborough, and examples of the deduction processes used.

The next witness was Sir Arnold Hall, who agreed with the comments made by Mr. Ripley concerning Redux. Asked whether the missing bolts from the panel on Comet YY "could have had any deleterious effect on the aircraft which might have resulted in the accident at Naples," Sir Arnold replied, "On the question whether it could have had, probably the de Havilland company is a better witness than I am. On the question whether it did have, my opinion is that it did not. . . ." The bolts went back into place without difficulty, Sir Arnold went on, and it was clear that the aircraft had not suffered any permanent distortion as a result of the absence of the bolts.

Concerning the decision to allow the Comets to resume flying after the Elba accident, Sir Arnold pointed out that the withdrawal of any Certificate of Airworthiness was the responsibility of the Air Registration Board. "The statutory authority for the airworthiness of civil aeroplanes is the Air Registration Board, and so far as the Air Safety Board is concerned it is not in any sense a statutory authority for airworthiness. It therefore started on the assumption that the Air Registration Board's recommendation was soundly based; and, of course, Lord Brabazon (who is the President of the Air Registration Board, and also a member of the Air Safety Board) saw Mr. Walter Tye, the Chief Technical Officer of the Air Registration Board, and had it from them that the Air Registration Board had no intention of withdrawing the Certificate of Airworthiness; indeed, they regarded the aircraft as airworthy."

The Air Safety Board then had to consider whether it should recommend an alteration to the A.R.B. decision.

Sir Lionel Heald: Will you tell his Lordship and the Court now what considerations the Air Safety Board had to have and did have in mind, in coming to the conclusion whether they should recommend the Minister and the Air Registration Board to change their views? —Yes. Of course, the first one was that the cause of the disaster at Elba had not been established. That was drawn to the Minister's attention here in those terms, and the question that had to be considered was, what was the chance that it would be established in a direct as opposed to an indirect way? That, I suppose, depended (it seemed to me at the time) on what was the possibility of recovering a substantial part of the wreckage. The Chairman of the Air Safety Board said the other day (and I agree with him; it was my opinion at the time) that the chance was then thought to be exceedingly remote; and there was a very good technical reason for that opinion.

The wreckage trail of YP, Sir Arnold went on to explain, was unusual—although consistent with the hypothesis put forward as to the cause of the accident. The wreckage of the Calcutta Comet, believed to have broken up at about 7,000ft, was spread over a five-mile trail; this was a normal ratio, and on this basis the wreckage of YP (from a height of 30,000ft) would be expected to fall over a distance of about 20 miles. This trail would be expected to run back along the aircraft's track from the location of the largest pieces of wreckage; in this direction, in the case of the Elba Comet, the depth of water increased rapidly, and there was an unswept minefield.

In the event, Sir Arnold went on, the wreckage was concentrated in a much smaller area—an exceptional feature caused by the exceptional nature of the pressure-cabin disruption. This, and the fact that the sea-bed was hard, sandy, flat and free from rocks, had permitted the recovery of much more of the wreckage than could possibly have been expected.

The chance of eventual success when the R.A.E. Comet investigation was first suggested, Sir Arnold stated, was remote, but "since it was quite plain that the only alternative was that the great enterprise that the Comet represents should be killed, we took it on. I think it probably helps to get this whole matter into perspective if it is realized that we poured on to this investigation resources such as (anyway in my experience) have never been poured on to an accident investigation and which certainly could not have been poured on to it without Ministerial direction. I deployed very large resources in terms of men and money and material. I drove my staff, and incidentally myself, well beyond normal limits. The Court may be interested to know that we had a very large deployment of industrial labour working 80-hour weeks and we had a large number of men that we drove to 100- and 120-hour weeks in order to get this matter forward."

After Sir Arnold had produced for the court a list of the dates on which the major items of YP wreckage had been received at Farnborough, he referred to the first fatigue failure on YU in the pressure tank, which had taken place on June 24th. There was no sign on the wreckage of YP of a corresponding failure at the escape hatch—neither was there any similar sign on the opposite side of the fuselage. Attention was then focussed on the top of the cabin, and the Naval search re-oriented in the hope of finding the missing wreckage from this area. Five weeks later, on August 12th, what turned out to be the vital piece was recovered, although at the time it was not recognized as such.

Summing up the reasons for his personal agreement with the Air Safety Board recommendation of March 5th, Sir Arnold mentioned first the remoteness, already described, of the chance of recovering much wreckage. Secondly, was there any connection between the accidents at Calcutta and Elba? These had happened respectively at 7,000ft in a Bengal nor'wester and at 30,000ft in clear weather: there was no family resemblance, and if there was any common element at all it was likely to lie in possible fire or explosion. These had been guarded against by the modifications following the extensive investigation at London Airport.

Future Testing

For the future, Sir Lionel Heald asked, was it possible to devise a programme of tests which would enable a guaranteed safe life to be decided for a given pressurized cabin? Sir Arnold believed that this was possible. In the case of a new aircraft, he said, one ought first of all to look at it and identify the part where fatigue was most likely to strike first. Partial tests on, say, six specimens of this part should be made in the laboratory, in order to establish their safe fatigue life.

"I think," he continued, "it might also be necessary—and with a new aeroplane I think it probably will—to take a complete specimen of the aircraft and put it to test in rather the way we put the Comet YU on test at Farnborough. If you do that, there will eventually be a failure from fatigue, no doubt. Let us suppose that it is at a window, though it might be, of course, at some other place. What I would then do is to take partial specimens involving that window, and I would have a hoop of the cabin (not just the single window and equally not another complete cabin) and make half a dozen of those, and test those partially, and secure the best design for that partial specimen.

"Meanwhile, I would have the whole aeroplane tests carried on until the next failure took place, and then take half a dozen of those. . . . If you can take half a dozen specimens and get a safety life, we would then put the variation as 3 : 1 on either side of the average. Whereas, if you only work on a single specimen, you would have to give a safety life of about one-ninth of what the specimen comes to, because the specimen might by chance have been the strongest. . . . It seems to me the sort of way in which one would go about ensuring the structure against fatigue at a cost in terms of material which is perhaps not too unreasonable. . . ."

One would end up, Sir Arnold concluded, by having either a guaranteed safety life which exceeded anything one wanted when the aircraft was sold commercially, or one would know which part had to be changed after a certain number of hours. He personally certainly did not take a pessimistic view concerning the possibility of curing this trouble in the Comet: "I am sure it can be cured, and I hope it will."

In reply to questions by Mr. L. G. Scarman (for the A.R.B.), Sir Arnold said that, after the first failure of the cabin of YU in the tank at Farnborough (at the equivalent of 9,000 hours) two repairs were made, one to the section which had broken, and one to another crack which would have developed into a second major failure. The test was continued, and the next catastrophic failure due to fatigue occurred at about 17,000 hours.

Mr. Scarman next questioned the witness concerning the future certification of the Comet and the various specific weaknesses in the aircraft, in addition to the short fatigue life, which had been mentioned in the R.A.E. report.

Questions on past and present knowledge of the problem were next asked by Mr. J. M. Shaw (for the relatives of a number of the deceased passengers and crew-members). Sir Arnold said the main piece of new knowledge which had arisen was that a specimen which passed a static test of twice its normal loading could nevertheless have in it stress concentrations of 70 per cent of the ultimate. Questioned

THE COMET INQUIRY: THIRD WEEK . . .

at length concerning the manufacturing cracks found in YP, Sir Arnold reaffirmed that he personally would prefer the use of a manufacturing process that would not cause such cracks.

Mr. Shaw: If you had known of these manufacturing cracks in March, as a member of the Air Safety Board, would your advice to the Minister have been the same?—No, it would not.

What advice would you have given?—I should have had the aeroplane inspected with extreme care in these vulnerable areas, and had those pieces removed.

Mr. R. A. MacCrindle (for the British Air Line Pilots' Association), after inquiring about the stress levels around cut-outs, and the possible advisability of the Air Safety Board's recommendation being changed in the light of subsequent developments, asked, "Assuming that none of your lengthy investigations had taken place at all and it had been suggested to you—if you like, in 1953—that a pressurized aircraft like the Comet, which had flown in the Naples case only 2,700 hours, had disrupted through metal fatigue, would you have agreed at that time?—I would have said it sounded an extremely curious story to me, assuming the aeroplane was an airworthy aircraft.

Would it have sounded equally curious to you had you been told there were in parts of the pressure cabin stresses of 70 per cent of the ultimate?—It would then have seemed a good deal less curious.

Mr. T. H. Tilling (for the Navigators and Engineer Officers Union) asked Sir Arnold whether the position of the compression buckle on YP was not consistent with the failure starting at the forward port corner (where a manufacturing crack was found) of the rear A.D.F. aerial window, rather than at the rear starboard corner (where a fatigue crack was identified). Sir Arnold replied that this was a valid point, which had been considered; but, as the crack would have spread extremely quickly, the exact source of the failure could not be traced with certainty merely by observing the position of the buckle. Further questions concerned stressing procedure in the initial stages of an aircraft's design, and the progressively increasing significance of the YP wreckage during the R.A.E. investigations.

Tuesday, November 2nd: Ninth Day.—The early development of the Comet, with special reference to R.A.E. and A.R.B. connections, was described in detail by the director and chairman of these two organizations respectively. Lord Brabazon of Tara, after outlining the statutory positions of the A.R.B. and the Air Safety Board, went on to give his personal impressions of the story of the Comet. The cause of the Elba accident, he said, was "the adventurous, pioneering spirit of our race."

Under continued cross-examination by Mr. Tilling, Sir Arnold Hall gave further details of the R.A.E. tests, and of the various possible causes of the Elba accident that had been considered (with special reference to the pressurization system and incorrect use of the flying controls), and amplified his remarks on the uncertainty of tracing an exact source of failure from a study of the associated compression buckle.

The witness was next cross-examined by Sir Hartley Shawcross (for de Havillands) and agreed that no aircraft had hitherto been subjected to such an examination as that of the Comet. The investigation would have taken at least two years in the ordinary course of events.

Sir Hartley: Having now had this very exhaustive examination and testing, are you able to say that, provided a thicker-gauge skin is used and there is some strengthening of the fuselage and wings, there is no inherent defect in the design of the Comet which would prevent it flying again?—I think, provided steps are taken on the lines you have just described, this aeroplane should go back and have a very successful career.

The Royal Aircraft Establishment, Sir Arnold agreed, had taken an interest in the early development and testing of the Comet prototype. In 1947 it had been decided that the wings should be submitted to repeated loading tests, but that static testing would suffice for the fuselage.

Safe Fatigue Life

After mentioning the early calculations and measurements that had been carried out, Sir Hartley turned to the Farnborough tank test on YU. Asked whether the probable position of a fatigue failure was unpredictable, Sir Arnold replied that, in general, fatigue was more likely to strike at a point where static failure also would be experienced, as that would be the point at which the highest stress would act. Had the maximum stress in the cabin been 50 per cent of the ultimate and not 70 per cent, he thought that the safe fatigue life would certainly have exceeded 5,000 hours.

Sir Hartley: I think what is done in normal commercial practice in this country (and military practice I dare say, too, in this country and in America) is to ensure that the laboratory and factory testing of each particular part of the aircraft appears to give it a life well in excess of the life it will actually have flown in service?—Yes, that is the usual practice.

It may be a comparatively short life in relation to the hoped-for life of the aircraft as a whole, but it ought to be in advance of that life?—It ought to be in advance of the exposure that particular aircraft has had in service.

In that way new parts are introduced, say wing spars or joints, as occasion requires, before any danger has arisen in relation to them?—Yes.

After some discussion as to the time when the need for repeated loading tests for pressure cabin fatigue had first been realized, and on the question of present and future official requirements in this matter, the 18,000-cycle test of de Havillands on the Comet (which corresponded to 54,000 hours) was mentioned.

Sir Hartley: Would you agree that, that test having been made in 1953, it was not unreasonable for de Havillands to think that the fuselage would have, I do not say a 54,000 hours' life, but a fatigue life considerably in excess of anything that had actually been flown?—I cannot entirely agree with that. This result was, in my opinion, achieved because the specimen had been pre-loaded in a static test to 13½ lb on several occasions, and to 16 lb on some occasions, and that if a specimen is so exposed, you get a release of stress concentration due to plastic flow, and the specimen may (and I emphasize the word "may") have a very much longer life than it otherwise would. . . . I would not like to put a particular figure on the ratio covered by this word "may." I would certainly not like to say that it is necessarily not worse than 10 to 1. Therefore if one got 54,000 hours on a pre-loaded specimen, I do not know of any basis on which one could then predict that the fatigue life of an unpre-loaded specimen would be X at all.

At the time of the test, Sir Arnold said, the de Havilland company were in no sense in serious violation of good practice or of general opinion, although they were probably in violation of certain areas of opinion.

The first witness in the afternoon session was Lord Brabazon of Tara, chairman of the Air Registration Board, who first gave to the Court details of the history, organization and work of the Board. Concerning the Board's consideration of the Elba accident, Lord Brabazon said, "Well, of course, there had been another one before that. There had been the Calcutta accident. That was a strange accident, occurring at 9,000ft. Great experts had gone into it, and they told us that the aeroplane had met weather conditions—I think it was a downward gust, they said, of 90 ft/sec on the tail—so extraordinary and so unprecedented as to be capable of breaking any machine in the air . . . those were circumstances under which we felt that an aeroplane should not have flown, and we had to leave it at that.

"Most Remarkable Machine"

"When the Elba accident occurred we did not connect the two in any way. The Elba accident was a completely unexplained accident to us at that time. But you have to remember this, the Comet was a machine which was being talked of all over the world as being, as it was indeed, the most remarkable machine in the world. We never took the action of grounding them, and I think it is wise to let you know straight away that if you grounded the type of every aeroplane that had an unexplained accident you would scarcely have a machine in the air today. That is what we have to realize. We saw nothing in that accident which justified us in grounding it.

"Here I would like to bring up an experience in the past. You remember the Tudors. Two Tudors disappeared. They were minutely looked into. I was in charge of the second investigation. We could find nothing wrong. But what did we do? We went through the aeroplane with a fine comb, we thought of every possible thing that could have occurred, and sequence of events that could have occurred, and we modified them with many modifications. We never discovered the cause of those two accidents, but what resulted was that there were no more. The Tudor IV flew again, and has not suffered from any disaster. It may well have been that in those alterations we effected the cure, but to this day we do not know what effected the cure. It was the same thing in the Comet I. We recommended that an investigation should take place, that the machine should come back and be looked at by all the experts in the world, and you have heard, I think, from Abell the way that was done."

After the London Airport investigations, Lord Brabazon went on, "The Air Registration Board considered all the alterations that we had made. We thought everything possible had been done to make the thing safe or even safer than before, and we wrote a letter to the Minister—I have it here—which said: 'Referring to my recent letter, I am now able to tell you that the Board has given the fullest consideration to the Comet situation and has reviewed in detail the work of all parties to the investigations which have been undertaken. Although no definite reason for the accident has been established, modifications are being embodied to cover every possibility that imagination has suggested as a likely cause of the disaster. When these modifications are completed and have been satisfactorily flight tested, the Board sees no reason why passenger services should not be renewed.'"

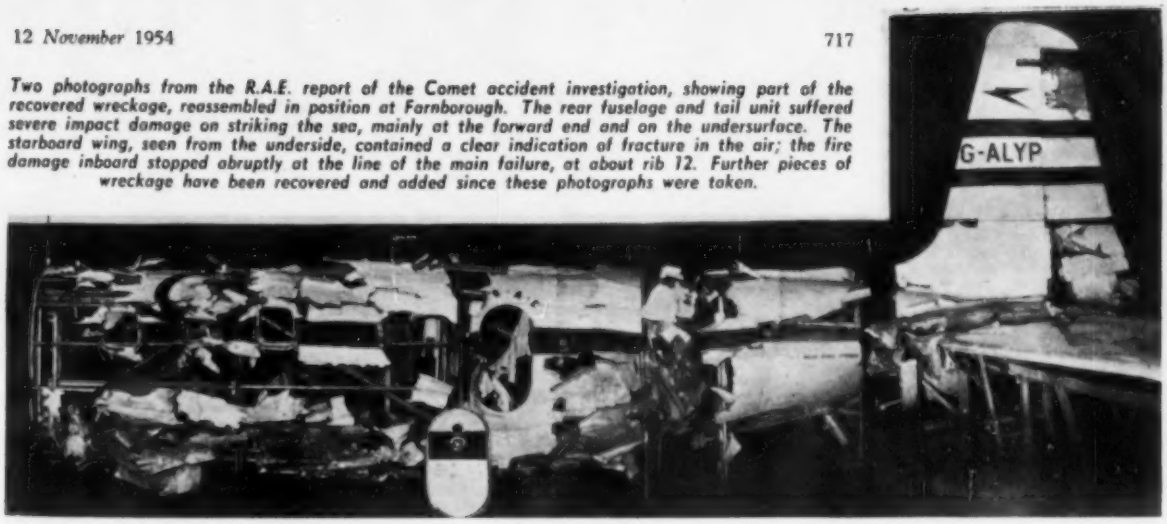
Before cross-examination, Lord Brabazon was asked by Sir Lionel Heald to give the Court briefly his experience "in relation to the development of aircraft in the last few years, based, as we know, on a lifetime spent in aviation."

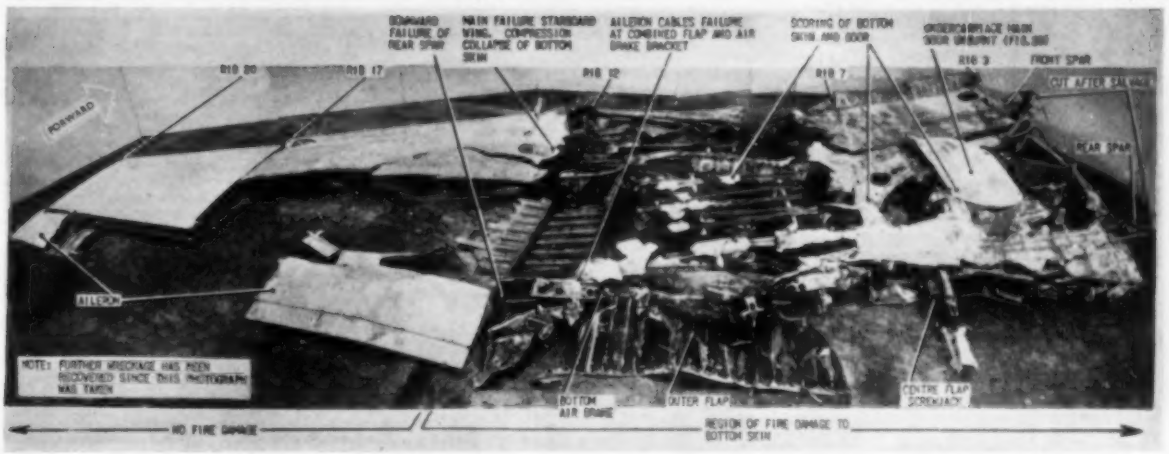
Lord Brabazon addressed the Commissioner, Lord Cohen: "It is a little difficult. First of all, I know you, my Lord, are charged with this duty of trying to find a physical reason for these disasters, and you may even try to find a scapegoat. I am quite prepared to be that scapegoat, because it is true to say, is it not, that the Air Registration Board, of which I am Chairman, could have forbidden the Comet to fly at all. . . .

"You know and I know the cause of this accident. It is due to the adventurous, pioneering spirit of our race. It has been like that in the past, it is like that in the present, and I hope it will be in the future. In this inquiry there is nothing to be ashamed of; much more to be proud of. Here was a great imaginative project to build a machine with twice the speed and twice the height of any existing machine in the world. We all went into it with our eyes wide open. We were conscious of the dangers that were lurking in the unknown. We did not know what fate was going to hold out for us in the future. Of course we gave hostages to fate, but I cannot believe that this Court or our country will censure us because we ventured. You would not have the aeronautical people in this country trail behind the world in craven fear lest they be censured in such a Court as this for trying to lead the world. Everything within the realm of human knowledge and wisdom was put into this machine. . . .

"When we gave this certificate of airworthiness to these machines they were airworthy. True they deteriorated in a way no one on earth at the time could foretell, and they deteriorated, so I am led to

Two photographs from the R.A.E. report of the Comet accident investigation, showing part of the recovered wreckage, reassembled in position at Farnborough. The rear fuselage and tail unit suffered severe impact damage on striking the sea, mainly at the forward end and on the undersurface. The starboard wing, seen from the underside, contained a clear indication of fracture in the air; the fire damage inboard stopped abruptly at the line of the main failure, at about rib 12. Further pieces of wreckage have been recovered and added since these photographs were taken.





understand, by a slowly developing molecular metallurgical fault. It is metallurgy, not aeronautics, that is in the dock.

"My Lords, I have now had fifty years connected with aviation, and if I may say something about it I would like to say this, that in every step in progress we have paid for it in blood and treasure, and God knows that in this case we have paid in full.

"Finally, I do hope that the threat of having to face an inquiry such as this, with all its publicity, if anything goes wrong, will not stop adventurous spirits pioneering in the future."

Lord Cohen: There is only one criticism I would make of that. You said that our duties were to search out troubles. I assure you that is not our duty at all. Our duty is to find out the cause of the accident, and it looks, so far as the physical cause you have mentioned is concerned, as though it may be a comparatively simple task, having regard to the course of the inquiry. The far more important thing is whether the evidence discloses that the trouble can be put right and the Comet can take the air again, and it is that aspect of the question which leads to a great many of the questions put.

In the subsequent cross-examination by counsel, Lord Brabazon described how the Board kept in touch with developments in international civil aviation. It had followed closely the development of the Comet from the beginning, and had available to it the technical advice not only of its own staff but virtually of the whole of British industry. Lord Brabazon had seen no reason to hold a further A.R.B. meeting to reconsider the decision not to ground Comets after Elba.

In a discussion on the information before the Board when it made its decision after Elba, mention was made of the two unexplained accidents to Avro Tudor aircraft, after which modifications had been made and the type had flown again successfully. During his cross-examination, Sir Hartley Shawcross quoted details of an unspecified American aircraft which had experienced fuselage cracks: this type, he said, had had "five unexplained disasters" and was still flying.

Next, Sir Arnold Hall was again recalled, for continued cross-examination by Sir Hartley Shawcross. Details were given of the R.A.E. tests on the wing of the prototype Comet, which began in 1953. The first crack appeared at 5,500 hours, but in a section unrepresentative of the production aircraft: the first representative crack appeared on December 21st after 6,700 hours, after which a special inspection procedure was instituted in B.O.A.C. It was seen that a life would have to be put on sections of the wing in due time.

The question of manufacturing cracks was again raised, and Sir Arnold then agreed that the effect of his evidence was, broadly, that a manufacturing crack might tend to foster fatigue at the point where it existed, because it was a stress-raiser.

Thursday, November 4th: Tenth Day.—Sir Arnold Hall, Dr. P. B. Walker and Air Marshal Sir Victor Tait gave evidence on this day. Sir Arnold continued to give Sir Hartley Shawcross (for de Havillands) further details on points already discussed: Dr. Walker spoke of fatigue, fatigue-testing and the safe life of the Comet; and Air Marshal Tait, operations director of B.O.A.C., described the Corporation's background and operational history with the Comet.

Continuing his cross-examination of Sir Arnold Hall, Sir Hartley Shawcross asked whether the presence of a crack in an otherwise perfectly safe pressurized fuselage would make the aircraft liable to catastrophic failure. Sir Arnold replied "The whole question of what we might call crackology depends entirely on what is the stress in the vicinity of the crack and in what sort of stress field the crack finds itself. If it is pointing towards a rising stress, plainly it is getting encouragement to go ahead. If the aircraft you have suggested is so designed that the stresses are of a reasonable level throughout it, then I would have no particular worries about the cracks; but if, on the other hand, it is designed so that it has points of very high concentration of stress, then in those areas alone I would be troubled in my mind about cracks."

The designer of an aircraft should have regard to possible maintenance accidents, Sir Arnold said; but, if the aircraft had been properly designed and built, i.e., if it contained no excessive or abnormal stress concentrations then a small crack of the order of 0.2in caused accidentally would not imperil it. If an aircraft was such that a crack of 0.2in did imperil it, then there must be something wrong about it.

Referring to the Comet's elevator break-out force of 20 lb, Sir Hartley suggested that the chances of an accident through someone falling against the stick were less than if the break-out force were zero. Sir Arnold replied that this was not so, as a man weighed more than 20 lb: what was relevant, however, was the stick force per g. A B.O.A.C. report had confirmed the opinion of the Farnborough pilots that the Comet would be a better aircraft if it had a smaller elevator break-out force; as previously stated, however, this feature had not caused the Elba accident.

After confirming that adequate and reasonable precautions had been taken against the danger due to hydraulics and electrics being in the same equipment bay in the Comet, Sir Arnold dealt with the danger of possible damage to the wing during refuelling. In certain circumstances, he said, the wing structure could be damaged during refuelling, but the strength of the wing would be decreased by only

THE COMET INQUIRY: THIRD WEEK . . .

20 per cent—well inside the safety factor of the aircraft. It seemed improbable that this would cause an accident; it certainly did not cause the Elba accident; but on the whole it was advisable to avoid that kind of thing.

Another point to which the R.A.E. report had called attention was that fuel, after escaping from the vents in the wing, could reach very near to the tail-cone shroud. Sir Arnold commented: "We have demonstrated that a quantity of fuel can get down near a hot place, and all we are drawing attention to is that it is good practice to avoid fuel getting there." On one wing of Comet AV a modification had been introduced to prevent any fuel venting at all, which appeared satisfactory, but Sir Arnold thought a repositioning of the venting point was possibly a much simpler way. The ignition point of kerosine varied between 214 and 600 deg C.

The only other matter mentioned in the R.A.E. report was excessive vibration in the rear of the fuselage, due to jet efflux—"one of the new things being discovered in the operation of jet aircraft." After referring to these new problems, found on the Comet but applicable also to other aircraft, Sir Hartley said: "I think you have agreed there is no reason at all why, given proper attention to these considerations—using a thicker-gauge skin, for instance—this and other aircraft flying in similar conditions should not be perfectly safe?" Sir Arnold: "Not at all. I have very great faith in the future of high-flying civil aircraft."

The first afternoon witness to be recalled was Dr. P. B. Walker, who was cross-examined by Mr. Scarman concerning the Farnborough tank test on YP. The cabin failure at 9,000 hr equivalent, he said, took place during a proving test at 10.4 lb/sq in, and subsequent evidence of fatigue was found in the area of the failure. After this had been repaired, together with another, non-catastrophic failure at the same time, testing continued until a third failure at 17,000 hr equivalent.

Strain-gauge readings near the edges of side windows and A.D.F. aerial windows of YU, Dr. Walker said, indicated the potential danger of high stresses: stresses in these areas could be increased locally by rivet holes or other holes; while if a rivet or bolt carried loads, the whole stress field could be completely distorted. Fatigue tests made by Saunders-Roe on a riveted cylinder of the material used for the Comet cabin—D.T.D. 546—had shown a life of 8,000 cycles (approximating to 24,000 flying hours) for a stress of 30,000 lb/sq in. Mr. Scarman next submitted that, as there were 18 windows in the cabin of YU, 18 areas of high stress concentration were being tested simultaneously.

Mr. Scarman: In a sense, therefore . . . you had at Farnborough 18 specimens from which to draw an inference, did you not?—No. That is really cheating . . . as far as I am concerned, the aircraft is the specimen. . . . The more windows you have in an aeroplane, the more windows you are testing, but it is also the more windows you have that fail in an accident. . . .

If it had not been for the fact of Elba and Naples, would you have deduced as probable from your tank tests a fatigue failure at 2,700 hr?—We should have said that any Comet aircraft at that number of hours (2,700) was not safe to fly. . . . We would have advised great caution and probably more experimental work, but the probability is that we should not have agreed to the aircraft continuing flying.

"Well-behaved Material"

After discussing at length the expected scatter of fatigue life between different examples of the same aircraft, and mentioning that the quoted spread from one-third to three times the average was not a constant ratio, Dr. Walker described D.T.D. 546, used in the Comet cabin, as "a well-understood material, and on the whole a well-behaved material."

Enquiring further into the estimation of a minimum safe fatigue life from an average value, Mr. R. A. MacCrindle (for B.A.L.P.A.) was told by Dr. Walker that, for caution, the average would be divided by 3.5 or 4. Assuming the result of the tank test but no knowledge of the Elba and Naples accidents, Mr. MacCrindle then asked, what factor would have been applied to the 9,000 hr? Dr. Walker reaffirmed that it would have been considered that the Elba aircraft had entered the danger region, and probably the Naples one had entered it or was just entering it.

Assuming knowledge of the test result and also of the two accidents, Mr. MacCrindle asked, what then would be the approximate safe life? "I think I would say it was not worth flying at all," replied Dr. Walker.

Lord Cohen: Is not this the position, that you would say, "You must modify the design so as to increase the safety margin, and I cannot tell you what I will say until we know what modifications you propose?"—Exactly.

In reply to a further question by Mr. MacCrindle, Dr. Walker said that the fluctuation of outside air temperature during a flight, and the temperature gradient through the cabin skin, would not cause any significant alteration of the stress distribution. The effect of other factors such as vibration, landing loads, etc., which could not have been simulated in the tank test, was extremely difficult to estimate, but "If my life depended on giving an estimate I think I would pull that 9,000 hr down to perhaps 7,500."

The day's final witness was Air Marshal Sir Victor H. Tait, operations director of B.O.A.C., who outlined the principles of acquisition, licensing and operation of the Corporation's aircraft. Up to the time of the Naples accident, he said, the total number of Comet hours flown was 25,408 (involving over ten million miles' flying); the four oldest aircraft, YU, YP, YW and YS, had flown 3,521, 3,495, 3,417 and 3,245 hours respectively.

Friday, November 5th: Eleventh Day.—The state of knowledge of fatigue over the past eight years was discussed by Dr. Walker, who suggested that de Havillands might have consulted R.A.E. more during the early development of the Comet. The chief technical officer of the Air Registration Board outlined his organization's method of drafting airworthiness requirements, with particular reference to those for the Comet.

One of the assessors, Professor W. J. Duncan, first asked Dr. Walker what effect the temperature difference between YU in the Farnborough tank test and Comets in flight at cruising altitude would have on the aircraft's fatigue life. The witness replied that the effect of the lower temperature during flight would be to increase the fatigue life, though only by a small amount.

Amplifying what the witness had said in evidence the previous day, in view of publicity given to isolated quotations in the daily Press, Sir Hartley Shawcross asked: "You do not doubt, do you, that there is no reason at all why the Comet aircraft with a thicker-gauge skin and with strengthening in the wings should not have a long economic and successful life?" Dr. Walker: "I have no doubts whatever on that point."

Concerning the fatigue crack at the starboard rear corner of the rear A.D.F. window, Dr. Walker agreed that the bolt locating the skin to the frame at that point could have given rise to a special area of stress. He thought that the manufacturing cracks found probably did not shorten the life of the aircraft. The repeated-loading test on wing and pressure cabin of YU, Dr. Walker stated, was the first such combined test made in this country. Previous repeated-loading tests at Farnborough had included those on "foreshortened" cabins of the Apollo aircraft and another civil type.

The state of knowledge of fatigue since 1946 was next the subject of much questioning by Sir Hartley, who quoted extracts from several papers on the subject. Concerning his own paper on fatigue read before the R.Ae.S. in 1949, Dr. Walker pointed out that it contained no specific reference to pressure cabins: this aspect of the fatigue problem was indeed not fully appreciated at that time. Concerning the development work on the first two Comets, and the R.A.E.'s part in it, Dr. Walker said that he thought there ought to have been more co-operation from de Havillands. After stating that he personally did not know that a Comet nose-section was being built for testing in 1947, the witness was further questioned on this point, and said: "I think they could have come and consulted us more than they did. I am not saying it was a serious default."

Asked by Sir Hartley whether it was true that, until de Havillands decided to expose the Comet to repeated loadings in 1953, the structures department at R.A.E. had never sought to make that a requirement under the contract for the delivery of the two M.o.S. Comets, Dr. Walker said he thought that was correct. Sir Hartley submitted that the extrapolated figure in the R.A.E. report of 70 per cent of ultimate at the edge of a cut-out might be incorrect, as peak stress might be near a bolt or rivet and not at the actual edge of the cut-out. Dr. Walker said this could be so, but he would not have expected it; he thought the extrapolation was correct.

A number of technical points were then put forward by Mr. Tilling (for the Navigators and Engineer Officers Union). He first suggested, with reference to the manufacturing crack found on the port corner of the rear A.D.F. window, that although this crack if located by a drilled hole might not fail under working pressure, it could fail under working pressure if it had propagated beyond the hole. Dr. Walker agreed, and went on to say that fatigue would have been the cause of any such propagation: it was impossible to tell whether the crack had propagated.

Dr. Walker next agreed that the "wobbulation" or "tremolo" effect of working-pressure variation might reduce the fatigue life of the cabin. The decrease in pressure over the top of the Comet fuselage due to aerofoil effect, Mr. Tilling went on to suggest, might also have an effect. The "peak" of this pressure variation might have been located over the A.D.F. windows, Dr. Walker agreed, but he thought the effect was insignificant.

Cross-examined by Mr. Cripps (for the M.o.S.), Dr. Walker explained that, although the pressure cabin of YU was a representative test specimen up to the time of the first failure, at 9,000 hr, the area around that failure, subsequently repaired, was not thereafter representative. The rear fuselage failure at 17,000 hr was legitimate, but the absence of failure in the A.D.F. window region between 9,000 hr and 17,000 hr might not have been significant. Concerning his previously expressed opinion on the lack of co-operation between de Havillands and R.A.E., Dr. Walker agreed that the reason might have been that the procedure in this particular case did not allow as much consultation as the procedure in other cases in which he had been concerned.

The next witness was Mr. Walter Tye, chief technical officer of the Air Registration Board, who was first examined by Mr. J. P. Graham (for the Crown). Mr. Tye said that the constitution of the Council of the Board was designed to ensure that control of civil airworthiness matters should be exercised in the main by those who had a direct interest in it, no single interest having a preponderating control. He went on to outline the way in which the Board prepared its requirement (in which were embodied the I.C.A.O. standards of airworthiness), and to describe the delegation of responsibilities to approved firms.

The investigation of prototype aircraft was next described by the witness, both generally and in the specific case of the D.H. 106 Comet.

After initial special certifications, the full normal-category Certificate of Airworthiness for the Comet was issued on January 22nd, 1952. Variations from the Board's published requirements were that the machine had slight longitudinal instability at high speeds when at high altitudes; manually operated circuit-breakers could be overridden; there was a wing-drop at the stall, and also a violent stall buffet with flaps up, and there were no special instruments to show loss of power.

None of these was considered unsafe, however; none had any apparent connection with the Elba accident; and the requirements themselves were not mandatory but were rather a recommended code of engineering practice. Had any of these variations been considered sufficiently important, modifications would have been insisted on.

After tracing the history of the Board's requirements for pressure-cabin strength, Mr. Tye said that, at the time of the Comet's introduction, the proof and ultimate strength factors officially laid down were 1.0 and 1.5 respectively. The Board told manufacturers, however, that a proof factor of 1.33 and an ultimate factor of 2 (applied to the normal working pressure) were advisable in order to combat the relatively unknown factors of fatigue, crack propagation, creep, etc.

(To be continued)

British West Indian Airways, the Caribbean subsidiary of B.O.A.C., recently accomplished the largest troop-lift ever undertaken in that area. Vikings, two of which are seen, moved 2,000 Scots troops and members of their families between Port of Spain and Georgetown.

CIVIL AVIATION

B.O.A.C./B.E.A. HIRE-PURCHASE PLAN

A JOINT announcement by B.O.A.C. and B.E.A. on November 9th stated that deferred-payment travel was available from that date on the routes of both airlines. Under this plan, a passenger can book a seat or a number of seats for 10 per cent of the cost of the ticket(s) (or, if he wishes, a higher percentage) and can travel as soon as his proposal is accepted.

The balance of the cost of the ticket plus interest (which will be in the region of 11 per cent) is paid back in monthly instalments over a period. The period of repayment varies according to the amount of travel purchased: if the balance involved is less than £30 it must be paid back in less than six months; sums of £30-£100 are paid back over 12 months; and for sums of £100 and over the period of repayment is 21 months.

Deferred payment does not apply when the total transaction is less than £20. Groups of tickets costing less than £20 each can, however, be bought under the plan. Deferred payment is available, incidentally, on virtually all tickets bought through B.O.A.C. or B.E.A., even though the journey may be made with another airline.

There follow two examples of the B.E.A. plan: London-Zurich —return tickets costing a total of £69 13s, for two adults and a child, could be bought for a deposit of £6 13s and 12 monthly repayments of £5 16s 7d; London-Athens—return tickets for two adults, costing £194 8s, could be bought for £19 8s deposit and 21 monthly repayments of £9 18s 9d.

The B.O.A.C. plan would enable a passenger to fly from London to New York and back on a tourist service during the off-peak season for a deposit of only £15 16s, the balance being repaid over 21 months. The plan will not take effect, incidentally, on B.O.A.C.'s services to America until December 9th, since formal approval has to be obtained from the C.A.A. Similarly, hire-purchase air travel to Canada is at present the subject of government negotiations.

It is understood that backing is being furnished by City finance houses in the case of both B.O.A.C. and B.E.A.

ON SPEEDING-UP CUSTOMS

"A NUMBER of the Customs documents at present in use in their phraseology take no account even of the existence of air transport." This sentence is from an important memorandum on the need for reform of Customs procedure, drawn up by the Council of the Air League and sent to the Chancellor of the Exchequer and the President of the Board of Trade.

The memorandum criticizes certain anomalies which create discrimination against goods taken by air. An example is that elaborate documentation is required for air freight consignments, whereas for postal parcels of the same size, weight and value only one form is needed. Furthermore, the duty charged on the majority of imported goods is based on a "value" consisting of the sum of the cost of the goods plus insurance and carriage. Since air freight rates are relatively high, duty payable on an air freight consignment is therefore higher than if the same article were sent by post. Purchase tax is calculated on the cost of the goods plus insurance, carriage and import duty, and thus the air consignment is twice penalized.

The memorandum admits that Customs authorities have made several concessions in order to secure the minimum of delay in clearing airborne goods. It contends, however, that speedy handling of air freight should not depend on unofficial concessions which can be withdrawn at any time and says that legislation will be required to make further progress possible.

Another sore point covered by the memorandum is the question of extension of Customs facilities to additional airports. Ships have traditionally been free to put into any port capable of receiving them and consequently Preventive Officers are to be found at small harbours which handle nothing more in the way of foreign traffic than an occasional fishing boat or yacht. By contrast, the United Kingdom has only 22 airports with Customs facilities, and applications for additional facilities have been refused even when the operators concerned were prepared to pay the expense.

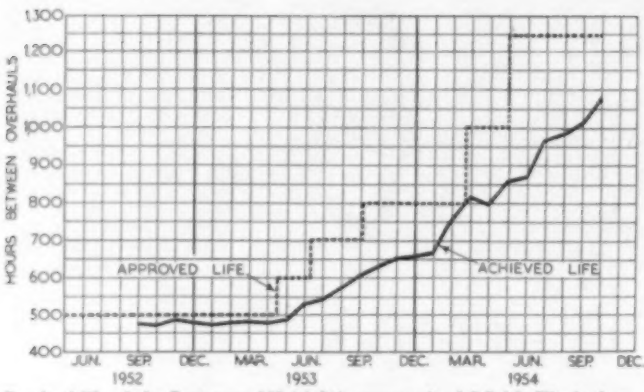
Summing up, the memorandum states that: "The whole question, as it appears to the air transport industry—and no doubt also to many industrial users of air transport—is whether an ancient Customs system which, with the growth of air transport, only continues to function through having been patched up with unofficial concessions, and reinforced by goodwill and personal relationships, is not ripe for recasting, to keep pace with the development of the air age, and the requirements of commerce in the world of today—and of tomorrow."

MODERNIZING MONTREAL

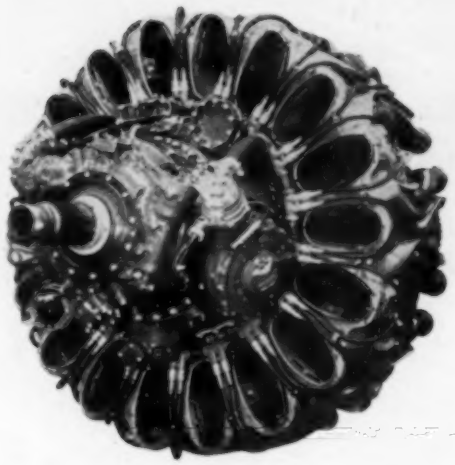
WORK begins next spring on a £10m programme of expanding and improving Montreal's airport at Dorval. The area of the airport is to be increased from 1,600 to 4,000 acres, and two new runways of 8,000ft and 10,000ft will supplement the two existing 7,000ft strips. Technical features of the improved airport will include a surveillance radar, a hydrant refuelling system and underground power-lines for starting and servicing on the apron.

A helicopter landing site will be situated near the new terminal building, which will handle both domestic and international services. Covered walkways will lead from the terminal building to the domestic and the international marshalling areas, each of which will be capable of accommodating from ten to twelve aircraft at a time.

Australia has become the 33rd country to adopt the Beaver bush transport. Shown here are a pair of four seven-seat (high-density) versions bought by Qantas for opening up inaccessible regions in New Guinea; one of the four will be fitted with floats.



Overhaul life of the Centaurus 661 (right), power-unit of B.E.A.'s Elizabethans, increased from 500 hr to 1,250 hr between May 1952 and May 1954 in the stages plotted above. The degree of reliability is indicated by the line showing achieved life, based on a six-month running average.



CIVIL AVIATION . . .

SPOTLIGHT ON THE CENTAURUS

EVEN though air travel has become commonplace, civil transport aircraft still work in a certain aura of glamour. This is certainly not true, however, of their power-units, despite the fact that engines—and the number of really significant engine-types is remarkably small—are the very heart of air transport. An engine is heard but scarcely seen behind its tight cowling, and the closer it approaches absolute reliability the less attention it attracts. Which is perfectly understandable, but not altogether fair, perhaps, to the designers and operators of the engine concerned.

A case in point is the Bristol Centaurus 661, which powers B.E.A.'s fleet of 20 Elizabethans. Following its introduction to B.E.A. service in March 1952, the Elizabethan passed through a rather trying period of teething troubles, but is now thoroughly settled down as one of the best medium-stage airliners in existence today. And all the while the Centaurus has progressed alongside to the point where it has been justifiably described by B.E.A.'s Chief Executive as "one of the most reliable aero-engines in the world". A major stage in its development was reached this summer when overhaul life was extended from 1,000 to 1,250 hr, which equals the interval between major airframe overhauls. An obvious economy results, in that engine changes are now normally made only when the aircraft goes into dock for its check for overhaul.

We learned last week from Mr. R. L. Ninnes, a director of the Bristol Aeroplane Company's Engine Division, that the transition from 1,000 to 1,250 hr marked an important change in the procedure for increasing overhaul lives. The first step towards raising engine overhaul life, is, of course, taken jointly by the operator and the manufacturer—in this case B.E.A. and Bristols. A case for a longer life is made out to the Air Registration Board, and it is agreed between all three parties that inspection of a given number of time-expired engines will be made: whether or not engine life can be raised then depends on the condition of the stripped-down components.

Formerly, the next step was to permit a certain number of engines to be operated to the new overhaul life before a final decision was made. This procedure was open to question in that what might conceivably be termed an experiment was being conducted with a scheduled transport aircraft carrying fare-paying passengers. Either it was safe to increase the overhaul life of all engines of that type, it was argued, or it was not.

In increasing the overhaul period of the Centaurus 661 from 1,000 to 1,250 hr, a new procedure was adopted. The first twelve engines to complete 1,000 hr were stripped down, inspected and found to be in excellent condition, and the life of all Centaurus 661s was thereupon increased to 1,250 hr. It is confidently expected that the overhaul life will be extended by a further 250 hr by the end of the year, though the number of engines to be inspected has yet to be agreed.

Already the first five Centaurus 661s to complete 1,250 hr have come up for inspection and the results are most encouraging. The first two were immediately bench-tested as received from B.E.A. and showed remarkably little deterioration: the first gave a take-off power of 2,560 b.h.p., compared with an output when new of 2,584 b.h.p.; the second gave 2,525 b.h.p., or 23 b.h.p. less than its output when dispatched to the operator 1,250 flying hours previously after a major overhaul. Oil-circulation rates, which are a useful clue to the degree of internal wear on engine components, showed virtually no change in either case. The 1,250 hr life of the Centaurus 661 is equal to that approved for all but a few civil Hercules, and compares favourably with those of the most "experienced" American engines of comparable output.

In the case of the Centaurus 661, the attainment of this life is believed to constitute a record, for it was reached after only 100,000 engine hours in airline service. This figure can be better appreciated if viewed as the outcome of two and a half years of moderate utilization in a fleet of only 20 aircraft—B.E.A.'s Elizabethans.

Mere establishment of long overhaul periods is, of course, meaningless. The reliability of the engine must be such as to give it a fair chance of achieving its full life. So far as the Centaurus 661 is concerned, the figures presented in graphic and tabular form on this page tell their own story: more than 80 per cent of the engines reach their full approved life before being removed from the aircraft, and the average achieved life exceeds 90 per cent of the maximum possible.

A brief look at the history of the Centaurus shows that, unlike most successful piston engines, it was placed in airline service without the benefit of an astronomical number of hours of previous operation in military aircraft. At the same time, it would

Reliability record: the performance of Centaurus 661s in B.E.A. service between January 1953 and October 1954. At the beginning of this period engine hours flown in service amounted to 21,552, the cumulative total on October 31st being 128,147.

		1953												1954									
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Monthly engine hours		2,184	2,340	2,776	3,414	4,892	5,684	5,504	5,544	5,466	4,576	3,800	3,601	3,817	3,322	3,844	5,415	6,696	7,031	7,484	7,646	7 510	6,232
Number of engine removals during month	Time-expired engines	3	5	3	6	6	6	3	10	12	2	1	0	1	3	4	6	8	0	8	2	3	7
	Engine failures detected on ground inspection	0	0	0	0	0	0	0	2	0	1	0	0	1	0	1	1	0	1	1	1	0	1
	Failures causing feathering of propeller in flight	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	1	0
	Removed prematurely for other reasons (no engine failure)	0	0	1	2	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1
Average life (hr.) of time expired engines removed during month		450	532	523	487	510	628	553	705	704	750	790	—	800	1,000	870	958	990	—	1,232	1,265	1,125	1,163
Percentage of possible engine hours achieved (six-month running average)		90.8	89.8	91.0	90.8	90.9	95.4	96.1	91.2	92. 4	92.9	92.7	91.8	90.7	96.4	93.0	84.6	88.8	88.6	91.1	92.5	89.2	90.5

1904
1954

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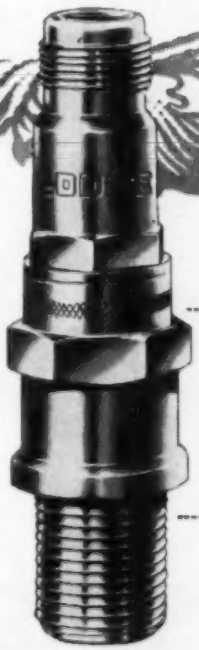

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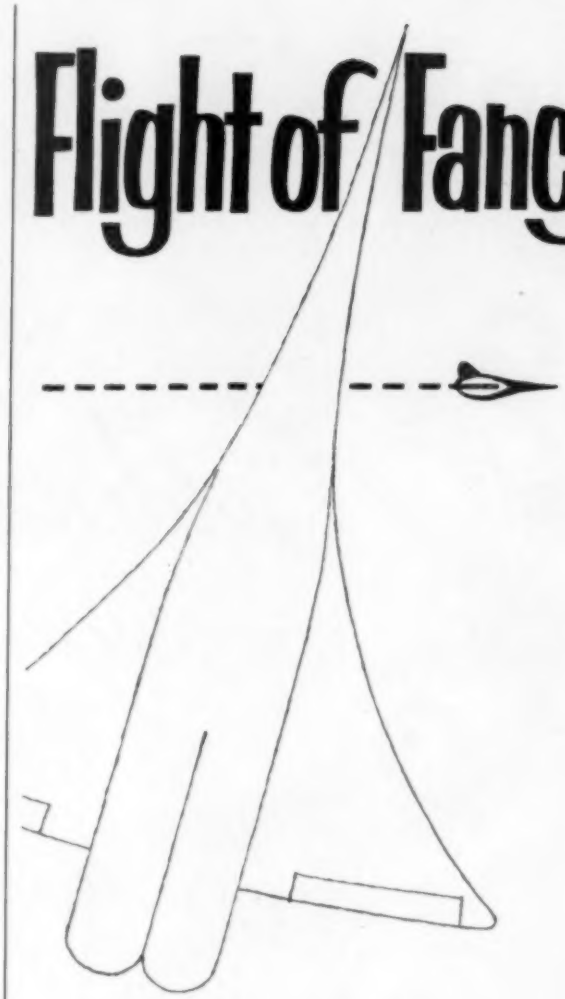

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CIVIL AVIATION . . .

be incorrect to suggest that its basic features had not been proved. The Centaurus was first bench-run in the summer of 1938 and first flew in the Warwick about two years later. It was subsequently used to power three twin-engined Bristol aircraft (the Brigand, Buckingham and Buckmaster), the Firebrand strike fighter, and the Tempest II and Sea Fury fighters. The engine was originally selected by Mr. A. E. Hagg, designer of the Ambassador (as it then was) in 1943.

His original requirement was for 2,400 h.p. at take-off and 900 h.p. for cruising. This was subsequently up-rated to keep pace with increases in the aircraft's payload and weight, and the net installed take-off power of Centaurus 661s in the present-day Elizabethans is 2,625 b.h.p. Cruising output averages 1,200 b.h.p., with 1,300 b.h.p. as the maximum. Further increases in the power of the Centaurus would present no difficulty. The 673 version for the Blackburn Universal Freighter will, in fact, deliver 2,850 b.h.p. with water methanol injection, and this does not represent the top limit of development.

The Centaurus 661, as used in the Elizabethan, differs in several respects from the military 630 series. The differences include improved cooling, strengthening for higher output and the fitting of torquemeters and reversing airscrews. Of the 5,000 or so Centaurus built, 109 were examples of the civil version, this figure including prototypes. Virtually all modifications to the 661 design were embodied before the engine entered B.E.A. service.

Centaurus overhaul is undertaken by Bristols in the ex-B.O.A.C. hangars at Whitchurch, where the company's engine division also handles Hercules, R-3350s from R.A.F. Washingtons and J47s from Canadair Sabres. The spares pool of Centaurus 661s is owned by Bristols; B.E.A. own only the 40 engines actually installed, plus the few spares required for immediate replacements. The airline pays for overhauls on a flying-hour basis, the cost per hour being calculated on a sliding scale according to the number of inter-overhaul hours achieved (the more hours achieved, the lower the cost).

Portrayed here are the holders of three new appointments announced by Vickers-Armstrongs, Ltd. From left to right are Mr. J. A. MacD. Henderson, formerly secretary of I.A.T.A., who is now customer liaison representative for the aircraft division at Weybridge; Mr. W. J. Young, who, as supply superintendent in Washington, will administer the supply of all Viscount spares and equipment to Capital Airlines; and Mr. R. H. Botterill, technical liaison representative with Capital Airlines.

OVER THE POLE

ON Monday a S.A.S. DC-6B will set off from Copenhagen to inaugurate the Scandinavian airline's new Polar service to Los Angeles *via* Sondre Stromfjord and Winnipeg. At both refuelling points slip crews will take over the aircraft. The DC-6B carrying the slip crews was due to begin its positioning flight yesterday.

Aircraft operating the new route will carry a crew of ten—three pilots, two navigators, two flight engineers, two stewards and a stewardess. For the past year selected crews have been attending special Arctic flight courses in Copenhagen.

BREVITIES

BOTH of Australia's state-owned airlines made profits in the financial year ended June 30th, 1954. The international carrier, Qantas, made £441,472, and T.A.A. earned a profit of £91,528. In each case the sums quoted are in pounds sterling.

* * *

Sudan Airways recently inaugurated a twice-weekly service between Khartoum and Cairo. The service, which calls at Wadi Halfa in each direction, is operated by 22-seat DC-3s.

* * *

The A.R.B. has approved a 40 per cent increase—from 1,000 to 1,400 hr—in the overhaul life of de Havilland propellers fitted to Bristol 170 Mk 31 and Mk 32 aircraft.

* * *

As expected, the loss of T.A.A.'s first Viscount will delay the introduction of scheduled services with the new aircraft. The first Viscount service will now be inaugurated on December 18th instead of November 15th.

* * *

P.A.W.A. announce the appointment of Mr. James J. Rice as traffic/sales manager in Sweden. Mr. Rice, who joined PanAm 13 years ago as a steward, has been in London for the past eighteen months as the airline's district assistant traffic/sales manager.

* * *

The Brazilian airlines R.E.A.L. and Aerovias Brasil are reported to have placed a joint order for eight Convair 340s, with delivery to be completed by January 1955. Whether or not the order is additional to one placed earlier by R.E.A.L. for four aircraft of this type is not yet certain.

* * *

America's two leading domestic freight airlines, Slick Airways and the Flying Tiger Line, have applied to the C.A.B. for permission to abandon their recent merger agreement. American Airlines, who claim that "the all-cargo carrier is an uneconomic and unnecessary unit for air transportation," have urged the Board that the certificates of both companies should be revoked. It is reported that, if the C.A.B. approves the application, Flying Tigers will withdraw voluntarily from the freight business.

By the middle of next year it is expected that all B.O.A.C.'s head-office staff at Airways House, at Brentford, will have transferred to the new engineering and administrative headquarters at London Airport. Airways House has been sold privately to a buyer who does not wish his name to be disclosed, reportedly at a price of £750,000.

* * *

Aer Lingus are disposing of two of the four Bristol Wayfarers ordered at the end of 1951 and introduced to service in the summer of 1952 as an interim measure. Delivery of the airline's four Viscounts was completed in June, increasing capacity by 40 per cent and allowing the Wayfarers to be withdrawn from passenger service on the London, Paris and Amsterdam routes.

* * *

Reduced fares on north and central Atlantic services were introduced on November 1st and will remain in effect until March 31st next. The first-class return fare between London and New York, for example, has dropped from £257 5s to £228 12s, and the tourist return fare for the same route is £151 16s, compared with £186 10s.

* * *

On return to the United States after a tour of Europe, Mr. Ralph Bell, sales director of the Boeing Airplane Co., said he had received a number of inquiries from European airlines regarding possible purchase of Boeing Stratoliners powered by British engines (presumably Conways or Olympus). He added that the cost of this civil version of the Boeing 707 would be about $3,850,000 (£1,380,000).

Eagle Aviation were among companies busily occupied on freighting as a result of the dock strike. Loads carried by the company's Dakotas on more than 20 flights to and from Holland included magazines, radio and car parts, gin, polish, cakes and sweets (outbound) and, inbound, cheese, butter and—shown here—liqueurs.

A formation of Australian-built Canberras on their way from Amberley, near Brisbane, to intercept Naval units during the recent combined exercises.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

R.A.F. Badge Altered

BY command of the Queen, St. Edward's crown is to replace the present Tudor crown in all designs embodying a representation of the Crown. All unit badges approved since Her Majesty's accession already bear the St. Edward's crown.

Two Squadron Standards Awarded

IT is announced that the Queen has approved the award of Squadron Standards to No. 57 Squadron R.A.F., and No. 504 (County of Nottingham) Squadron R.Aux.A.F.

No. 57 Squadron was formed on June 8th, 1916 and served until disbandment at the end of 1919. It was re-formed in October 1931. By many it will be remembered as taking part in pre-war Royal Air Force Displays at Hendon—flying Hawker Hart day bombers. Now No. 57 is equipped with Canberras, and last Friday the squadron left Cottesmore for a training flight to the Middle East. The present C.O. is S/L. I. G. Broom, D.S.O., D.F.C.

The squadron's ten battle honours, from which eight will be selected for the standard, are: Western Front 1916-1918; Amiens; France and Low Countries 1939-1940; Norway 1940; Channel and North Sea 1940; Ruhr 1941-1943; Fortress Europe 1941-1944; Berlin 1941-1943; France and Germany 1944-1945; Walcheren.

No. 504 (County of Nottingham) Squadron, commanded by S/L. P. I. Briggs, D.F.C., was first formed in March 1928 and served continuously throughout the last war until the Royal Auxiliary Air Force squadrons stood down in August 1945. It was re-formed in 1946. The battle honours which will appear on its Standard are: France and Low Countries 1940; Battle of Britain 1940; Home Defence 1940-1942; Atlantic 1941-1942; Fortress Europe 1942-1944; Normandy 1944; Arnhem; France and Germany 1944-1945.

H.M.S. "Bulwark" Joins Fleet

BUILT by Harland and Wolff, Ltd., in their Belfast yards, the aircraft carrier H.M.S. *Bulwark* was provisionally accepted by the Royal Navy on October 29th. On completion of trials and working up she will take over the duties of trials and training carrier from H.M.S. *Illustrious*, which is due to go into reserve. No specific squadrons will be allocated to *Bulwark*.

The new carrier is of the Hermes class, 737ft long with a beam on the water-line of 90ft. Her peacetime permanent ship's company is 76 officers and 960 ratings. Armament includes eleven multiple and single-barrelled Bofors guns, controlled by modern close-range director systems. Released details concerning the ship do not indicate whether steam catapults are fitted, but this is thought to be unlikely. The flight deck is angled, as on *Centaur* and *Albion*.

The Avro Canada CF-100 production line provides a background for a conversation between Air Chief Marshal Sir John Baker, Controller of Aircraft, M.o.S.; Air Marshal W. A. Curtis, vice-chairman of Avro Canada; and Air Marshal T. G. Pike, Deputy C.A.S.

New Sector Commander

FROM early next month G/C. J. Worrall, D.F.C., is to become the new Commander of the Eastern Sector, Fighter Command. He will assume the acting rank of air commodore. For the past year A. Cdre. Worrall has been Deputy Director of Organisation.

At the beginning of the war he was senior fighter controller in the operations room at R.A.F. Station, Biggin Hill, and in May 1940 he took over the command of No. 32 Squadron, then equipped with Hurricanes and stationed at Biggin Hill.

The new R.A.F. badge, with St. Edward's crown, referred to on this page.

Malayan Awards

BELOW is continued the list of awards recently announced for service in Malayan operations. The details concerning the awards are taken from the official citations:—

D.F.C.

Lt.-Cdr. G. C. J. Knight, R.N., No. 848 Squadron, R.N., who has been the senior pilot of No. 848 Squadron since its formation. He arrived in Malaya in advance of the squadron and paved the way for its arrival so efficiently that the squadron was able to commence operations within three weeks. Much of the squadron's success is due to his careful planning.

Lt.-Cdr. G. D. Luff, R.N., No. 848 Squadron, R.N., who has carried out the duties of senior observer tirelessly and efficiently since the formation of No. 848 Squadron and been with it since its arrival in Malaya. Lt.-Cdr. Luff has been responsible for developing the technique of navigation employed by helicopters on troop lifting operations into the jungle of Malaya and for the instruction of other aircrew in this technique. On numerous occasions he has been one of the first to disembark in unsecured Landing Zones in the deepest jungle where enemy activity is known to exist.

F/L. R. W. J. Andrusikiewics, who joined No. 110 Squadron in April 1952, and since has completed 136 operational sorties in the Federation. He has always shown exceptional zeal and ability and his determination to locate dropping zones and to carry out accurate drops in the most trying and hazardous conditions has been outstanding.

F/O. H. Marshall, who joined No. 48 Squadron in March 1952, and since has flown over 353 hours in support of the security forces in Malaya. Of this, 205 hours—consisting of 85 sorties—were flown in the last three months of 1953. In this time, by unselfish devotion to duty, he helped his squadron to achieve many records in the supply dropping rôle, one of which was the dropping of 848,000 pounds of supplies in November 1953. This represents

The new Hermes-class carrier H.M.S. "Bulwark," which was provisionally accepted by the Royal Navy on October 29th at Belfast. She is a sister ship to "Albion" and "Centaur." Capt. J. M. Villiers, O.B.E., R.N., is in command.

SERVICE AVIATION . . .

the highest month total dropped since the emergency started.

F/L. V. J. R. Hurring, who joined No. 110 Squadron in April 1952, and since has carried out 111 operational sorties on supply-dropping. He has continually volunteered for the most hazardous tasks. He has always accomplished these successfully, thus alleviating the conditions and hardships of the ground forces.

F/O. R. G. J. Sneller, who has served with No. 48 Squadron since October 1951. In his 2½ years with the squadron, he has flown nearly 1,900 hours, of which 288 hours were in direct support of the ground security forces. In the last 2½ months of 1953 he flew 170 hours on 69 sorties.

M.Plt. Cox, No. 194 Squadron, who joined the Far East Casualty Evacuation Flight in November 1952. Based at Changi, he carried out many casualty evacuations from all parts of Malaya. On the formation of No. 194 Squadron in February 1953, he moved to Kuala Lumpur. At this time M.Plt. Cox was one of the most experienced helicopter pilots in the Command. His knowledge of Malaya and the tasks required were invaluable during the formation of the squadron. So far, he has flown over 480 hours in helicopters during his tour of duty and he has personally evacuated over 80 casualties from jungle clearings..

Capt. V. K. Metcalf, Glider Pilot Regiment, No. 1911 L.L.F., R.A.F., who has been a pilot in No. 656 AOP/LL Squadron since September 1952. In June 1953, he assumed command of No. 1911 Light Liaison Flight, an appointment which he still holds. He has built up a most efficient Flight organisation at Seremban. As a pilot, Capt. Metcalf has shown great skill while flying over eight hundred hours in support of operations. His ability in finding enemy camps and clearings has been exceptional.

D.F.M.

F/S. C. Kirkham, who joined No. 81 Squadron in July 1951, as a pilot and, during the period of his tour has flown 1,405 hours, his total flying now being 1,964 hours. He has flown 354 sorties over Malaya on photographic duties and in addition has carried out 96 sorties on aerial survey and intelligence tasks over Borneo and Malaya.

(To be continued)

The C. P. Robertson Trophy

THE first award of the C. P. Robertson Trophy for the best interpretation of the Royal Air Force to the public was made last week at a reception of the Air Public Relations Association.

Lord Willoughby de Broke, chairman of the Association, made the presentation jointly to Mr. Denis Richards and Mrs. Hilary St. George Saunders, whose late husband, with Mr. Richards, wrote *Royal Air Force* 1939-1945, the official air story of the last war.

The memorial commemorates the late C. P. Robertson, who for many years was the head of the Press and Publicity Branch of the Air Ministry. Serving on the panel of judges were Marshals of the Royal Air Force Lord Tedder and Sir William F. Dickson, Lord Willoughby de Broke, Sir Robert Fraser and Mr. Laurence Irving.

R.A.F. Appointments

RECENT R.A.F. appointments include the following: G/C. D. F. MacDonald to Bomber Command and W/C. P. C. Webb, D.F.C., to H.Q. Southern Sector for air staff duties; in command, W/C. Davies to Wythall; W/C. W. T. Dennis to Colerne and W/C. G. A. V. Knyvett to Driffield, both for administrative duties; W/C. J. R. Fraser, O.B.E., to No. 18 Group for technical staff duties; and W/C. R. K. Williams to H.Q. A.A.F.N.E. for staff duties.

Appointments to the Air Ministry include those of W/C. R. J. Marks to the Department of the Chief of the Air Staff, W/C. W. T. Mathieson to the Department of the Air Member for Supply and Organization and S/L. N. L. Letten (with acting rank of wing commander) to the Department of the Air Member for Personnel.

Hendon and the A.T.C.

THE mention of Hendon brings back immediate memories of Grahame White and of the other early pilots pylon racing at the week-end meetings at what was then called the London Aerodrome. A later generation will remember it for Aerial Derby and early King's Cup races and for the wonderful Royal Air Force Displays. Others, again, will recall it chiefly as the pre-1939 home of Nos. 600 and 601 Auxiliary Air Force Squadrons and No. 24 (Communication) Squadron.

Through all Hendon's history, however, runs a less well-known thread, which started in 1910, when a troop of Boy Scouts set up a permanent summer camp in one of the fields now forming the western corner of the present airfield. One of the duties of this troop was to provide messengers during air race meetings. W/C. G. M. Manners-Barrett, who recently gave up command of the Middlesex A.T.C., was the Scout master in charge of that troop.

Shortly before the second war, when the Air Defence Cadet Corps was formed, three squadrons were adopted by No. 24 Squadron; of these No. 16F (Wood Green) has been affiliated to Hendon continuously since then. During the war—with the name changed to the Air Training Corps—no fewer than 18 London A.T.C. squadrons were affiliated to Hendon for flying and ground training. Some of these trainees, after having joined the R.A.F., served later at Hendon as aircrew.

From 1951 to 1953, No. 142 Glider School was stationed at Hendon and a number of cadets obtained their gliding certificates, but, owing to the built-up nature of the surrounding area, this activity had to be transferred to Hornchurch.

At present A.T.C. flying and instruction takes place at week-ends and that required by schools affiliated to the station during the week. Flying is normally provided by No. 31 Squadron, but a proportion is also done in the Auster aircraft of No. 1958 A.O.P. Flight. Special long-distance trips are laid on as rewards for hard work.

With the retirement of W/C. Manners-Barrett, command of the Middlesex Wing has been taken over by S/L. B. L. Middleton, M.B.E. The liaison officer is F/L. J. R. Lloyd.

Lord Willoughby de Broke (left) presents replicas of the C. P. Robertson trophy to Mrs. Saunders and Denis Richards. (See "The C. P. Robertson Trophy," on this page.)

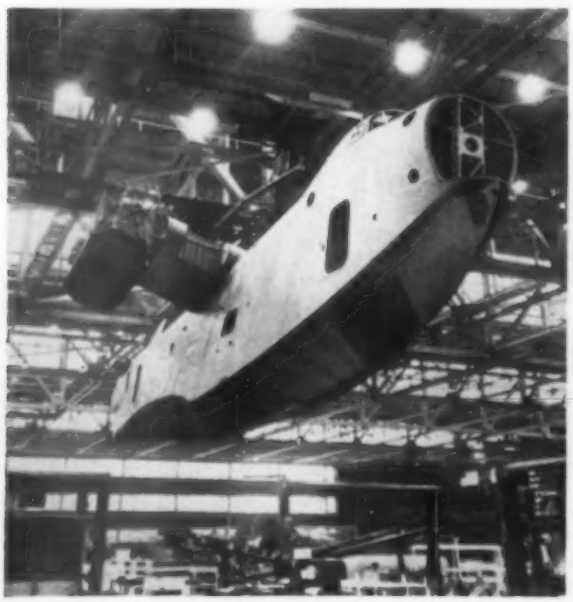
The output of B-57 Canberras from Martin's No. 2 plant at Baltimore is considerable, and could be trebled if necessary. Here, another comes off the line at midnight.

Housekeeping in Aircraft Production

The Glenn Martin Company's "Conservation Scheme"

UNDER certain forms of American military aircraft contract at present being fulfilled, the manufacturer can raise his profit margin by careful interior economy in all phases of production. The Glenn L. Martin Company have recently described in considerable detail the methods and effect of what they call systems management in reducing production time and cost and general wastage. All members of the company have, it appears, been made aware of the need for what can best be described as conservation in every phase of the company's work. The scheme is directed by a "conservation unit," but it is stressed that, for the full functioning of the scheme, the co-operation of all employees is necessary.

The description is given in a brochure, *Conservation—Everybody's Business*, which explains the functioning of the scheme in all its phases—product design, tooling, standards and methods, manufacturing, quality control, housekeeping and co-ordination. Firstly, in design, Martin stipulate that each item shall be designed from the start for economic quantity production, regardless of the quantities ordered. Thus, the prototype of an aircraft would be designed as a potentially produceable machine requiring no re-design work before it reached the production line. As outstanding examples, they quote various refinements in Matador and B-57 Canberra production. Materials and processes are carefully chosen; for instance, wing floats for P5Ms are now made of plastics. This particular float design resulted in a saving per float of $588 (£210) in cash and 83 lb in weight, principally through the elimination of rivets and by lower tooling costs.



In tooling, for example, a machine rig was also designed for milling the 128 lugs on the B-57 pilot's canopy ring tube which, including set-up time, saved no less than 39 hours' production time per unit. B-57 fuselage frames were stretch-formed instead of being fabricated by normal methods and it was found that eight frames instead of two could be made from a single sheet of metal. The life of drills, reamers and other tools was greatly increased by special heat treatment. Machining time was saved by devising methods of machining several parts together, or by arranging sliding work-tables on which one piece of work could be set up while another was being machined, thus saving idle-machinery time.

One of the principal factors in conservation is factory cleanliness, and the recovery and sorting of all waste. Parts are so planned that the minimum of sheet metal is wasted, and what is left over is then used again, if possible, or stored by grades and sold, ready sorted, to scrap dealers. All metal shavings and other left-overs are sorted and cleaned, and any usable nuts, bolts and other parts recovered are put back into use. All scrap —or, as the Americans call it, trash—is immediately swept up and put in bins according to grade, since scrap dealers pay a much higher price for ready-sorted scrap.

To facilitate what is termed the "housekeeping" side of the scheme, white lines are painted on the floor to show where mechanical sweepers pass, and bays laid out where clearly-marked bins are stacked for collection. All personnel are also made aware of the fact that, though nuts and rivets dropped on the floor will be recovered, they should not in the first place be allowed to go astray.

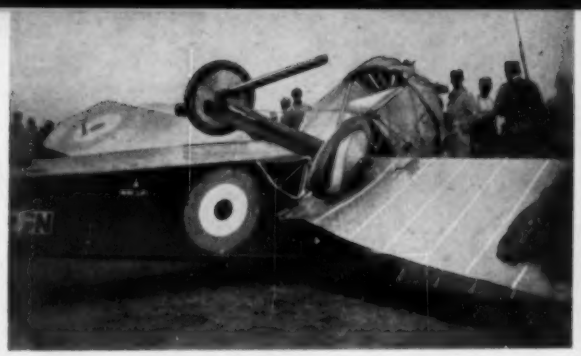
The handling of scrap is the responsibility of a special Conservation Metal Handlings Group. All usable recovered parts are cleaned and then sorted according to size, and records show that very large quantities of bolts, nuts and washers of all types are recovered. This "housekeeping" side of conservation is considered to be the critical phase. Since cleanliness leads to tidiness and tidiness prevents waste, this side of the work comes under the Plant Engineering Department.

In the whole production pattern, the conservation scheme fits in to what Martin's call systems management—"the utilization of known principles and techniques in obtaining an optimum result through orderly compromises achieved simultaneously with respect to the performance that is required and the momentary state of the art." This means that all sections of an aircraft or missile are designed in co-ordination with each other and in relation to the operational requirement for the final product, thus giving it the best chance of being right first time.

Another Martin product is the big P5M Marlin patrol flying boat, powered by Wright Turbo Compounds. These are test-flown from the waters of nearby Chesapeake Bay.

CORRESPONDENCE

The Editor of "Flight" does not hold himself responsible for the views expressed by correspondents in these columns; the names and addresses of the writers, not necessarily for publication, must in all cases accompany letters.



The R.E.7

From Air Vice-Marshal H. G. White, C.B., C.B.E., R.A.F.

WITH reference to the article entitled "The R.E.8"—in your issue of October 15th—you may be interested to know that one of the "remarkable" three-seat versions of the R.E.7, fitted with a Rolls-Royce Eagle engine, was in service with No. 20 Squadron in France about August, 1916 until it crashed on the date of its withdrawal on January 31st, 1917.

Its armament consisted of two free Lewis guns and one fixed Vickers gun firing through the propeller—including, on occasions, the blades. When in action the front gunner had to perch himself precariously on a Scarff ring fitted in the top centre-section, but all too frequently came adrift when rotating the gun mounting and invariably finished up in the pilot's cockpit.

The ingenious R.A.F. periscope bomb-sight was fitted for use by the pilot, but since not one of the many 500 lb bombs dropped from this aircraft was ever seen to explode, this excellent piece of apparatus proved to be entirely superfluous.

H.Q. Maintenance Command, H. G. WHITE,
Royal Air Force. Air Vice-Marshal.

Aircraft in Polar Exploration

WITH dismay I read the letter from Captain von Essen in your issue of October 29th, resulting from the article of Mr. Arthur Scholes, F.R.G.S., published by you on October 1st.

Anyone who sets out to write a review of exploration either in the Arctic or Antarctic, and who fails to spend a considerable time in research, is skating on thin ice. For the array of brave and skilful men who have through the ages in those regions pitted their energies against snow and storm, against cold and hunger, are legion—internationally legion. The task of discovering all these men's deeds and, having weighed them, of recording the events with complete fairness and without national prejudice is not to be undertaken lightly. But Mr. Scholes has undertaken it and brought criticism from a foreign party, who hints that the British official account also fails to give other participants credit.

The Norwegian-British-Swedish Expedition to Queen Maud Land was one of the finest instances of international co-operation which has ever taken place in Arctic or Antarctic. Anyone who has met Captain Giaver, the Norwegian leader, could well understand that a great measure of the success of the whole undertaking came from the top. It is therefore deplorable that any comment after the event should be made, tending to give the work of the expedition an appearance of international rivalry rather than of international co-operation, which was its true guise.

At least Captain Essen may have the satisfaction of knowing that in geographical circles there never has been any doubt about the value of the work of the Royal Swedish Air Force on the Queen Maud Land Expedition in surveying half a million square kilometres of Antarctica.

London, W.1. JOHN GRIERSON.

Mudros Memories

THE crash snapshot shows the Sopwith triplane mentioned by Mr. J. M. Bruce (October 29th) in his letter commenting on the "Strange Resting Place" described by "W.3643" (October 15th). At least, this was the condition, on March 26th, 1917, of the one Sopwith triplane, No. N 5431, in No. 2 Wing, R.N.A.S. The wreckage was brought back to Mudros and the aircraft was rebuilt and flying again within a few months, but I have no knowledge of its ultimate fate.

The crash took place on the Serbian airfield at Salonika. The pilot was none other than F/L. John Alcock, who overshot the small field and piled up on an embankment at the far end—the only piece of misjudgment I ever witnessed on the part of this superb flyer during long association with him during World War I.

Mr. Bruce's account of the formation of the "Composite Fighting Squadron" is quite correct. The Army had asked the Navy for help in combating the concentration of twin-engined bombers and Halberstadts which the Germans had brought to the Doiran front to destroy the huge supply-dumps around Salonika. I was in command of the R.N.A.S. element of the "Composite Squadron" during its existence and, thanks to the co-operation of the R.F.C. pilots assigned from the 17th Squadron, the Germans soon packed up and went elsewhere. We had several brushes with them in force, mostly on their side of the lines.

But back to the triplane. Four of us who were at Stavros on the coast of Greece, flying two-place Nieuports under W/C. J. R. W. Smyth-Pigott, D.S.O., were ordered to Hadzi Junas for this mission. We were re-equipped with Sopwith two-place 1½-strutters; and Jack Alcock, whom I had known well at Eastchurch in 1915-16, joined us with the one and only triplane in the Aegean area. We all based great hopes on this combination of pilot and aircraft, as we were confident the triplane's performance was superior to the 1½-strutters and also to that of the Huns. The five aircraft left Stavros on the morning of March 26th with a planned stop at Salonika; but, as I said at the beginning, Jack piled up the triplane and, having no replacement aircraft for him, we had to leave him behind.

The Sopwith triplane N.5431 in Salonika and, above, how it appeared after the crash (see letter from Mr. Eric T. Bradley).

It is obvious that the "candlestick" described by your correspondent "W.3643" could not have been constructed from parts of this crash, because one photograph plainly shows the blades broken off at the hub and the engine casing apparently intact. At the reunion dinner of No. 2 Wing R.N.A.S. on October 23rd (page 662, *Flight*, October 29th), I saw W/O. Jimmy Hoskins, R.N., who was chief of engine maintenance at Mudros during this period. Jimmy might well know what happened to N.5431 after rebuilding. He is farming somewhere near Salisbury.

London. W.1. ERIC T. BRADLEY.

IN BRIEF

Mr. H. J. Cooper is engaged in compiling a history of Brooklands Aerodrome, and would be grateful for the aid of readers in obtaining photographs covering the period 1909-20, showing the airfield, buildings, aircraft and people associated with aviation at Weybridge in those days. Such photographs should be sent to him at the Aviation Centre, 19 Park Lane, London, W.1.

FORTHCOMING EVENTS

Nov. 12. Helicopter Association: "Helicopter Production," by E. J. Boulger.
Nov. 13. R.A.F. College, Cranwell: Soccer v. R.M.A., Sandhurst.
Nov. 16. Helicopter Association (with the Engineering Society, Bristol University Engineering Laboratory): "Physical Aspects of the Aerodynamics of the Helicopter," by J. D. Sibley.
Nov. 16. R.Ae.S. Section Lecture: "Uses of the 'Ace' Computor," by Dr. E. T. Goodwin.
Nov. 17. R.Ae.S. Graduates' and Students' Section: "Bird Flight and the Aeroplane," by Capt. J. L. Pritchard, C.B.E.
Nov. 19. R.A.F. College, Cranwell: Boxing v. R.A.F. Officers.
Nov. 20. British Interplanetary Society (North-West branch): "Extra-Terrestrial Observatories," by C. A. Cross, M.A.
Nov. 20. British Interplanetary Society (provisional Yorkshire branch): "Space Vehicles," by D. A. Parish.
Nov. 23. Helicopter Association: Films, in association with the R.Ae.C.
Nov. 24. British Institution of Radio Engineers: "Direct Coupled Cathode Ray Oscilloscopes for Industry and Research," by M. J. Goddard, A.R.C.S., M.Sc., D.I.C.
Nov. 24. R.Ae.C.: Dinner for presentation of De La Vaulx Medals and Paul Tissandier Diplomas.
Nov. 24. R.A.F. College, Cranwell: Rugby v. R.A.F.

R.Ae.S. Branch Fixtures (to Nov. 24): Nov. 18, *I.O.W.*, junior members' evening. Nov. 19, *Belfast*, annual dinner; *Brough*, annual dinner dance.

Nov. 22, *Henlow*, "The Aeroplane and its Engine," by A. Cdre. F. R. Banks. Nov. 22, *Belfast*, "Plastics in Aircraft," by H. Baker. Nov. 23. *Boscombe Down*, "Bird Flight," by Capt. J. L. Pritchard. Nov. 24, *Bristol*, "User Problems in Industry," by B. S. Shenstone.

THE INDUSTRY

Bristol Capital Increase

TODAY, November 12th, shareholders of the Bristol Aeroplane Co., Ltd., are attending an extraordinary general meeting at Filton to consider proposals for new issues. These consist of the issue of 4,620,000 Ordinary shares of 10s, which will increase the issued ordinary capital to £6,930,000; the subdivision of a number of unissued and unclassified £1 shares into 4,240,000 Ordinary 10s shares; and the increasing of the authorized capital (to £10m) by £2m, divided into 380,000 Ordinary 10s shares and 1,810,000 unclassified £1 shares, which will be left unissued for the time being.

A statement issued in advance of the meeting says that the 1954 turnover of the company and its subsidiaries is expected to amount to over £30m, and that substantial production orders for the Britannia and for helicopters will lead to increased turnover in the future.

Electrical Protection

DEVELOPED for the exclusion of moisture from aircraft ignition systems, and from electronic and other circuits, a preparation known as MS 4 silicone insulating compound is the subject of a data sheet published by Midland Silicones, Ltd., 19 Upper Brook Street, London, W.1.

MS 4, it is explained, is a smooth silicone grease with the consistency of petroleum jelly—a character which is retained, essentially, over a temperature range of −50deg C to 200deg C. Among the advantages quoted for MS 4 in application to ignition systems are that it excludes moisture and makes treated surfaces water-repellent; prevents seeping along leads; prevents electrical leakages along insulating surfaces under conditions of condensation; serves as an auxiliary dielectric for cables and terminal insulation; helps to eliminate corona discharge at high altitudes; reduces tendency to "tracking" of insulation by arc discharge; reduces hardening of rubber, synthetic rubber and plastic insulations; and prevents corrosion of contacting metallic surfaces.

In electronic equipment, MS 4 is used as a sealing and potting compound for small transformers, capacitors, and similar details. The compound meets Specification D.T.D. 900/4298.

Incidentally, the new silicone plant at Barry, Glam, operated by Albright and Wilson, Ltd., will make Great Britain independent of outside supplies of this versatile chemical. Silicone-base products in increasing use in aircraft construction include (in addition to the insulating compound mentioned above), silicone rubber; paints to resist corrosion and high temperatures; greases; laminates for ducts, radomes, etc.; instrument fluids: and windscreen water repellents.

Mr. Archibald S. Bishop was last week appointed managing director of the Goodyear Tyre and Rubber Co. (Gt. Britain), Ltd. He joined the company in 1916, became general sales manager in 1933, and a member of the board three years later. He succeeds Mr. Walter A. Hazlett, a well-liked American who was appointed managing director of the British company in 1937 and who will shortly complete his 50th year with Goodyear.

Pye Technograph Agreement

IT was announced in London on October 26th that Pye, Ltd., of Cambridge, had acquired an interest in Technograph (Printed Circuits), Ltd. The latter firm, which was founded by Mr. H. Vezey Strong and Dr. P. Eisler, has pioneered the development of the printed-circuit technique, and now holds patents for such circuits in many countries. Although the printed-circuit method is applicable to most types of radio and electronic equipment, it has also been used in specialized applications such as the foil strain-gauges developed by Technograph and Saunders-Roe, Ltd. These were described in *Flight* of September 19th, 1952, and February 6th, 1953.

The Pye-Technograph agreement is not an exclusive one, although representatives of the Pye company have joined the Technograph board. Associations between Technograph and other companies are being negotiated.

IN BRIEF

Mr. James F. Tooley, comptroller of the aircraft division of Canadair, Ltd., has been elected a vice-president of the firm. Mr. John Urwin becomes acting secretary and treasurer.

* * *

The death is announced of Mr. W. R. Beldam, F.I.R.I., director of Auto-Klean Strainers, Ltd., and the Beldam Asbestos Co., Ltd. He founded the Auto-Klean company in 1923.

Mr. R. J. H. Branthwaite, B.A., A.M.I.E.E., appointed superintendent of the new electronic division of the development laboratories of R. B. Pullin and Co., Ltd. Creation of this post indicates that the company is now embarking on the design of a variety of electronic equipment. Mr. Branthwaite was formerly chief engineer of Furzehill Laboratories, Ltd.

Mr. J. H. Hutchinson, senior project engineer of the Hymatic Engineering Co., Ltd., has recently been making a three-week tour of the aircraft industry in France, Switzerland, and Italy; during it he has called on numerous firms using the company's products—snap jacks, hot air reducing valves and other airborne pneumatic equipment.

* * *

Siebe, Gorman and Co., Ltd., of Tolworth, Surbiton, Surrey, announce the appointment of Mr. R. P. Tanner, M.C.A.I., A.R.Ae.S., as development engineer, responsible for the development of the company's aircraft equipment. Mr. Tanner was associated with Siebe, Gorman and Co., in the manufacture of the pressure suit used by the pilots of the Bristol 138 which gained the world's altitude record in 1937 and 1938. He was subsequently engaged on high-altitude work with B.O.A.C. and with Canadair, Ltd.

* * *

Metalastik, Ltd., announce the appointment of Mr. Donald Bastow, B.Sc.(Eng.), M.I.Mech.E., as technical assistant to the managing director.

* * *

At the recent German Industrial Fair in Berlin, Cossor Radar, Ltd., exhibited, on the lawn outside the British pavilion, a 12-foot paraboloidal scanner of the type used with their small airfield radar. This particular type of scanner, combining low weight and considerable stiffness, consists basically of a sandwich of Dufaylite between two layers of Durestos.

* * *

On November 23rd and 24th the Metallurgical Laboratories of the British Welding Research Association at 29 Park Crescent, London, W.1, will be open to visitors. Work on both ferrous and non-ferrous alloys will be demonstrated, the welding processes including the argon-arc, metal arc and self-adjusting arc methods. Admission will be by ticket, obtainable on application to the Secretary of the Association at the address given above.

* * *

A.K. Fans, Ltd., of 20 Upper Park Road, London, N.W.3, announce that Mr. A. W. Dean, late of Marconi's Wireless Telegraph Co., Ltd., has joined them in an executive position. Increased factory space has been taken at 352 Goswell Road, London, E.C.I, for production of their range of axial and centrifugal fans; this range now extends over diameters from 1in to 72in, each size having volume/pressure-ratio variants.

* * *

To meet the demands made on the flexible-piping advisory service of the Compoflex Co., Ltd., in the Midlands and North of England, the company have opened a Northern Flexible Centre at their factory in Huddersfield Road, Oldham. A development section has also been started in Oldham, to deal with the design of special flexibles for particular projects. The first "flexible centre" was opened by Compoflex in London in 1952.

Photographically

Aviation relies on

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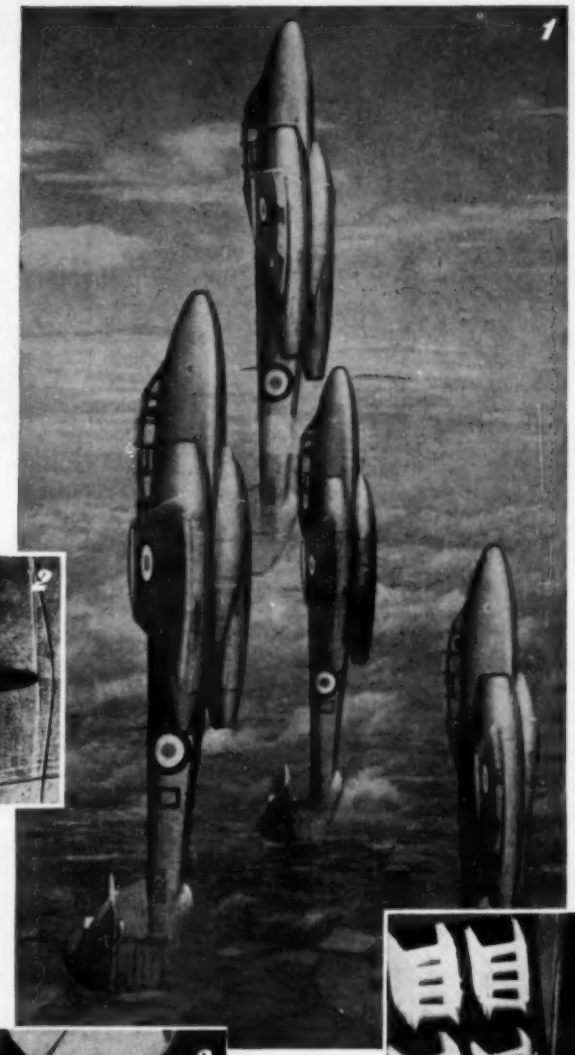
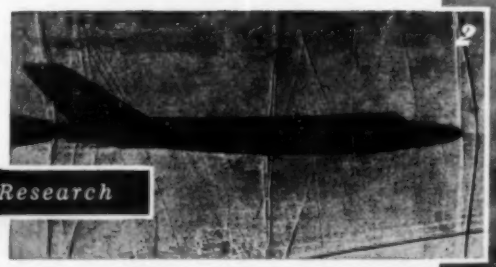
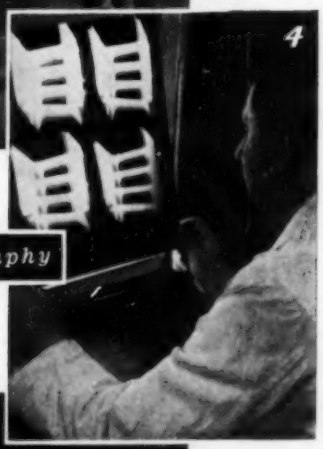




Research

In research and development, in design and production, photographic methods play a vital part—and in all these fields, the aircraft industry relies more and more on Ilford photographic materials.



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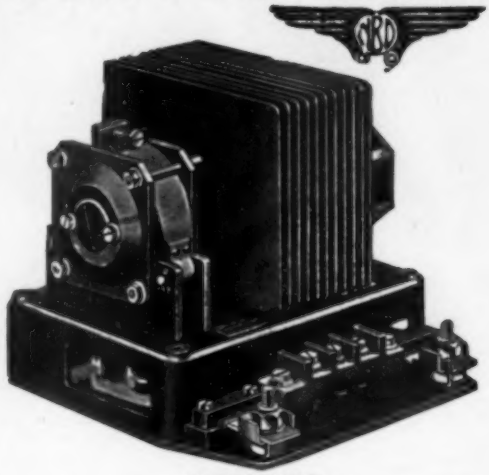

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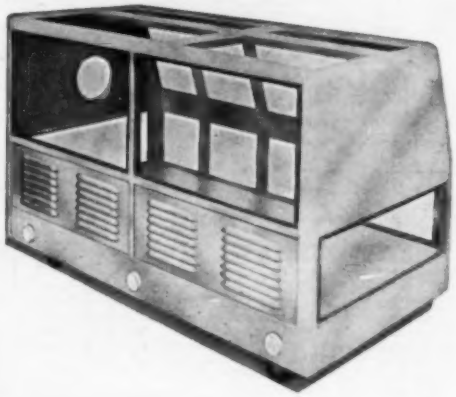

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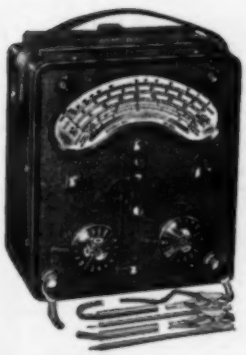

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A7/6

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17/6

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THIS application will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on July 30th, 1952. Any representations or objections with regard to this application must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3 Dean's Yard, London S.W.1, from whom further details of the application may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections.

THE Air Transport Advisory Council also give notice that the following applications have now been withdrawn:

APPLICATIONS Nos. 342 and 343 from Air Kruise (Kent) Ltd., of Lympne Airport, Kent, for Inclusive Tour Services with Dakota aircraft between Lympne/Ferryfield-Biarritz and Lympne/Ferryfield-Barcelona, respectively, which were advertised in *The Times* and *Flight* on September 10th, 1954 and in *The Aeroplane* on September 17th, 1954. [2860

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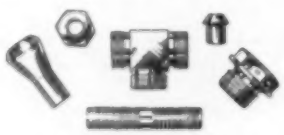

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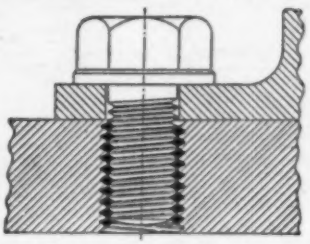

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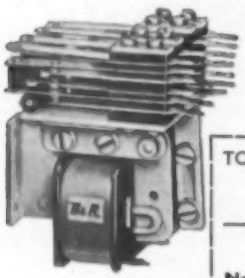

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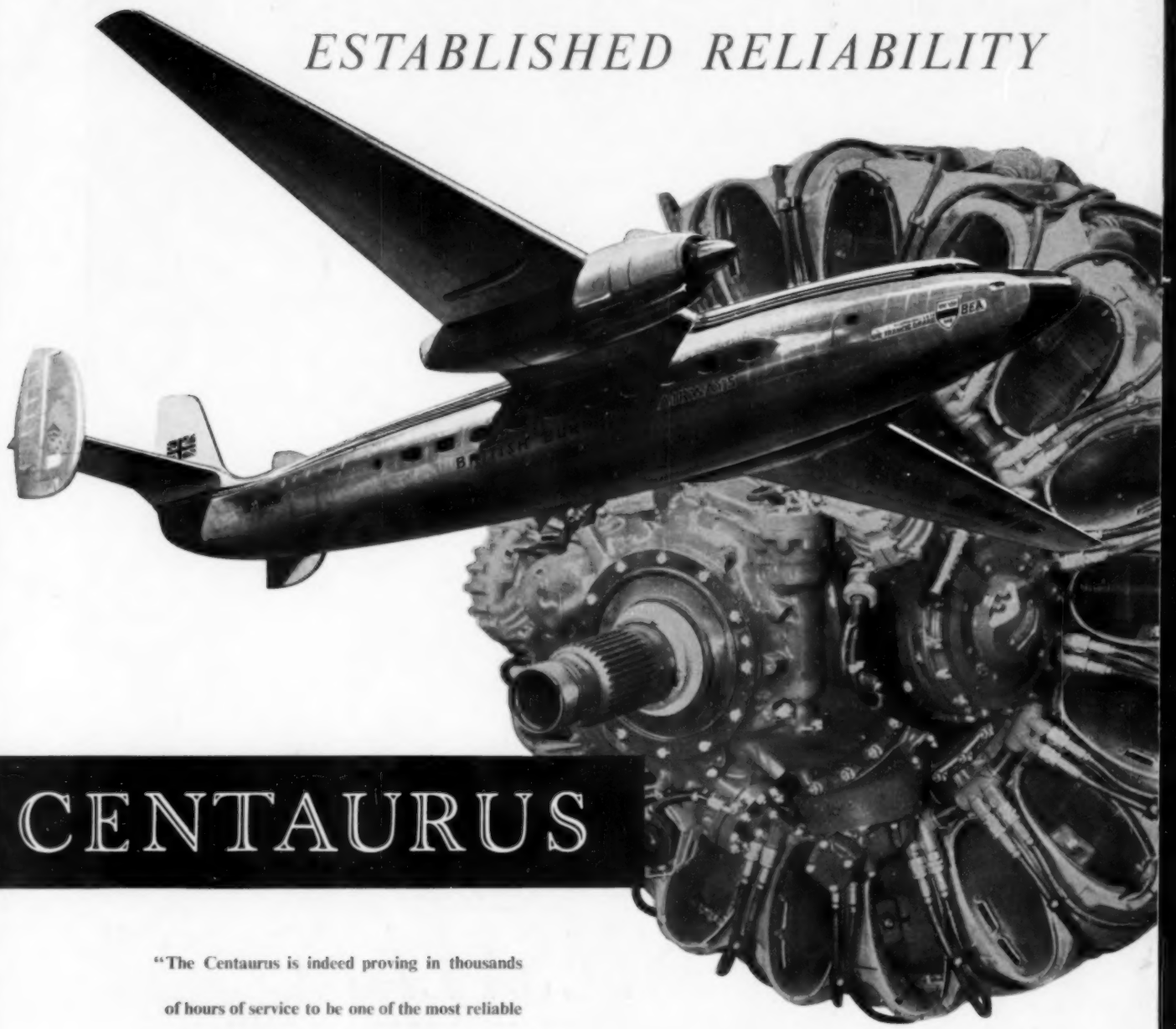

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